# Can Seasonal Climate Forecasting Improve California Energy Management?

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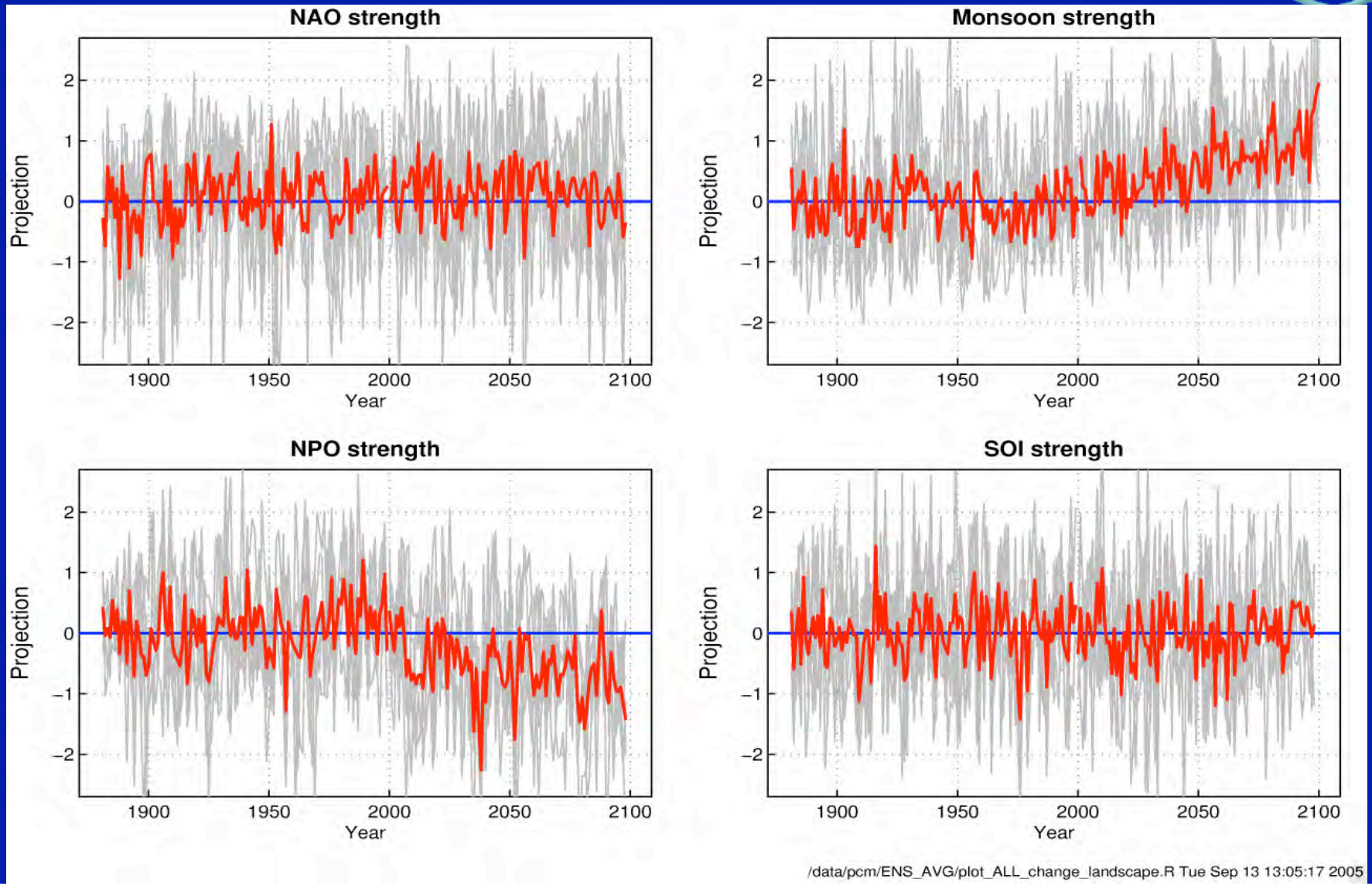
# Why examine seasonal forecasting?

1. Climate change might manifest as changes in El Nino or the Pacific Decadal Oscillation (PDO)

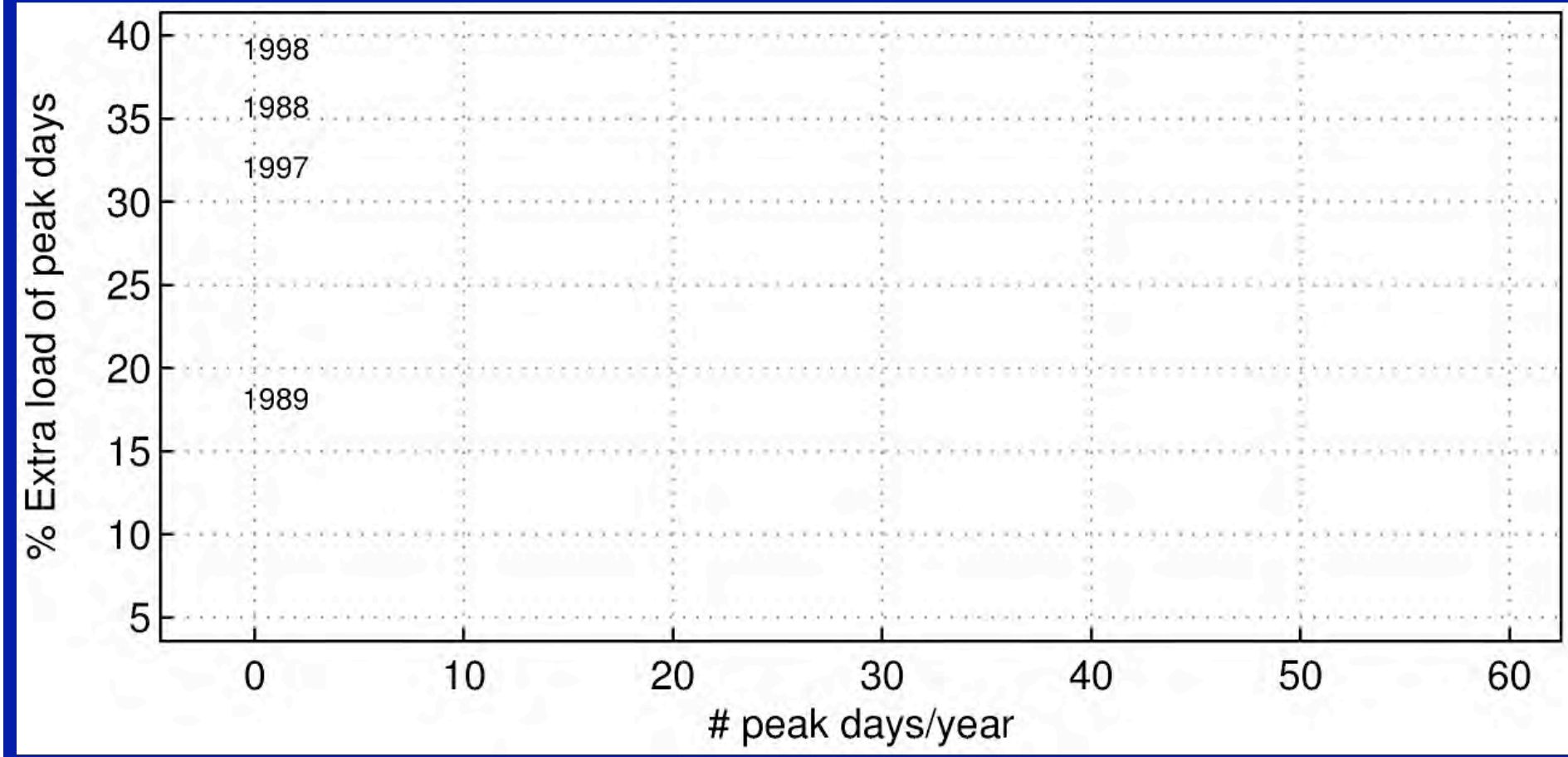
2. Energy industry *planning*: climate change
   Energy industry *operations*: seasonal forecasts

Part of the way climate change is *experienced*, and operationally *dealt with*, will be on seasonal timescales

# Seasonal modes & global change?



# Example 1: Summer electricity peaks



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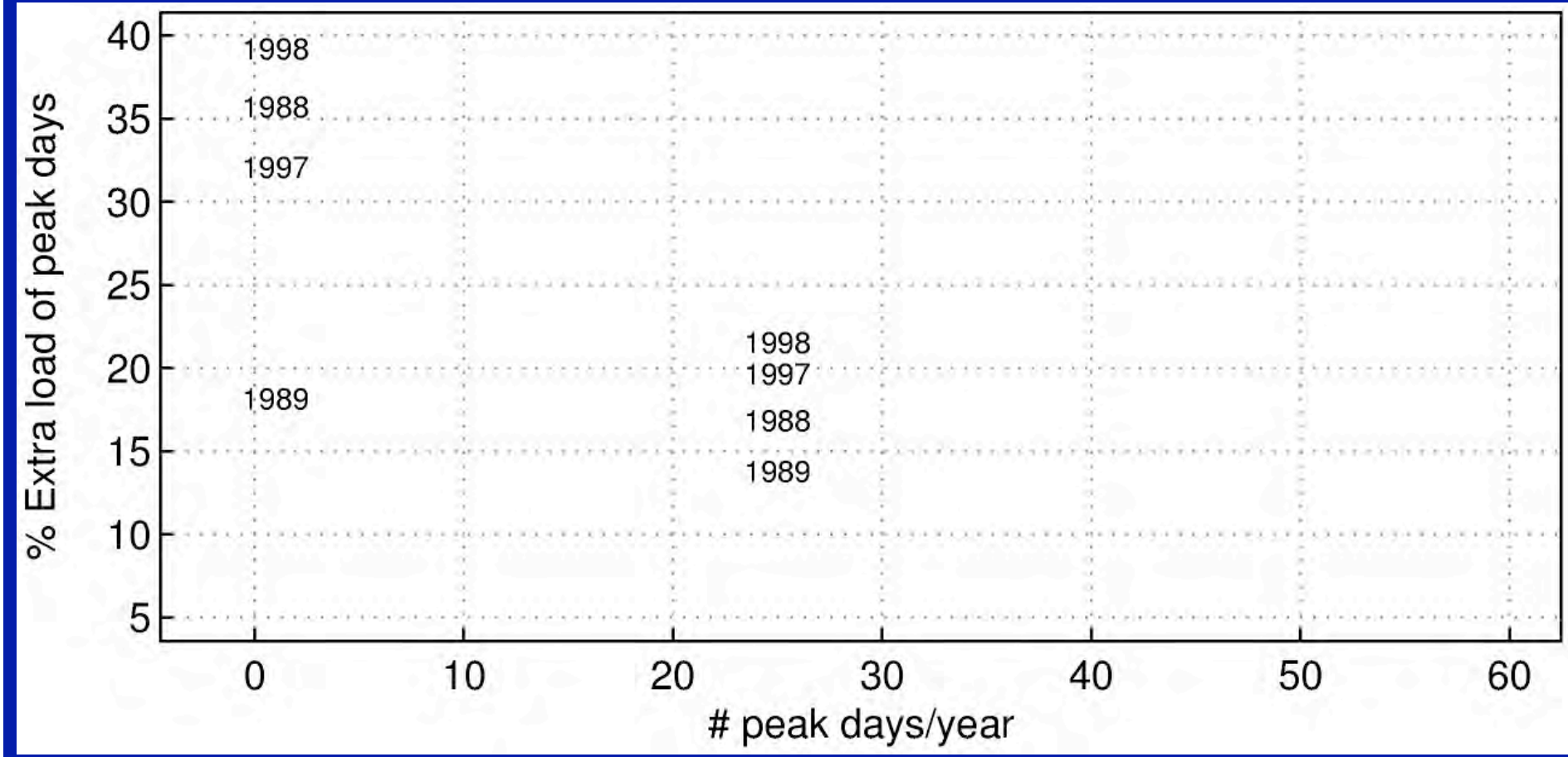

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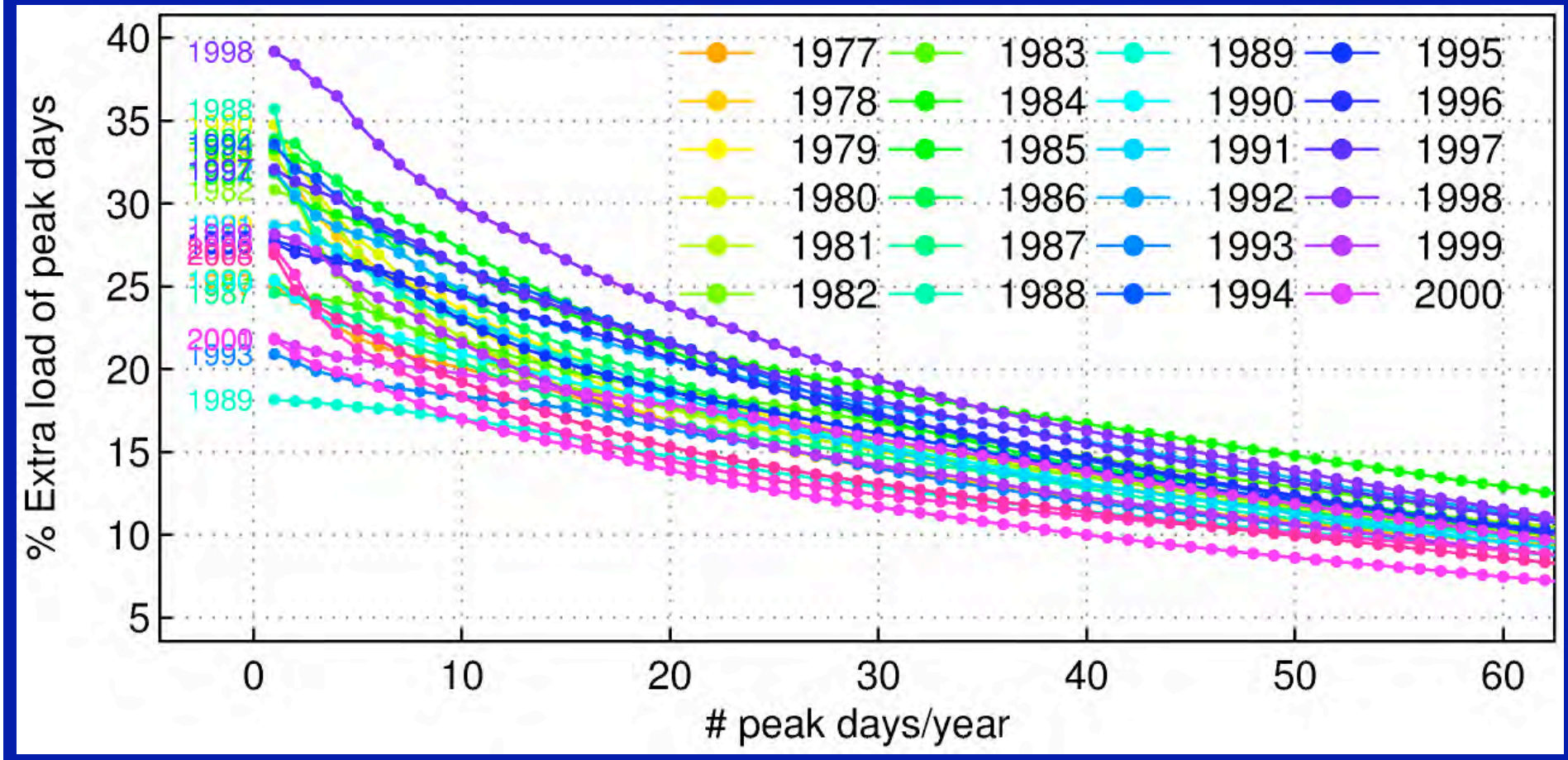

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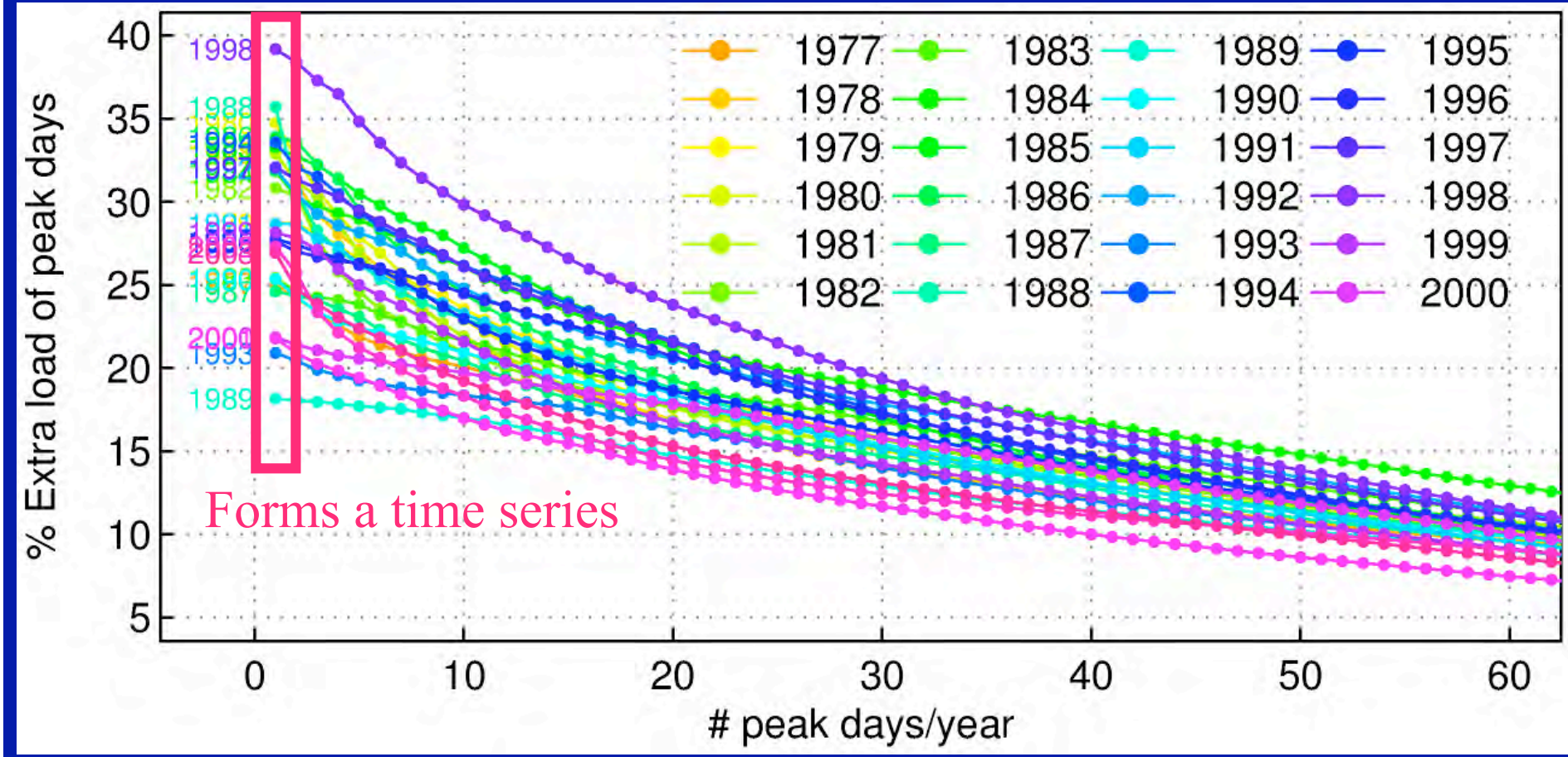
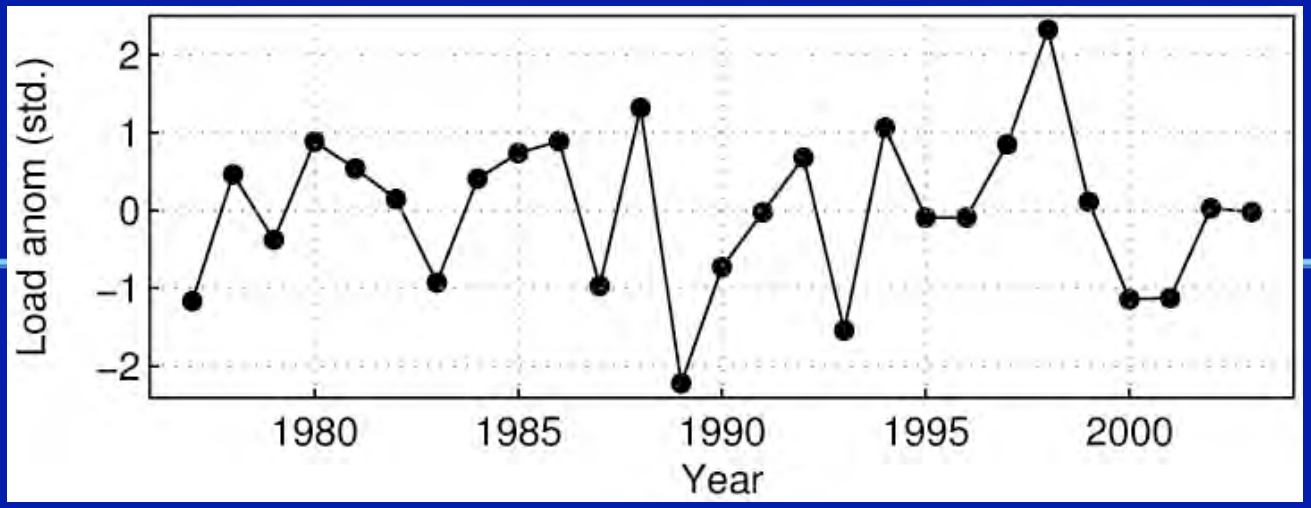
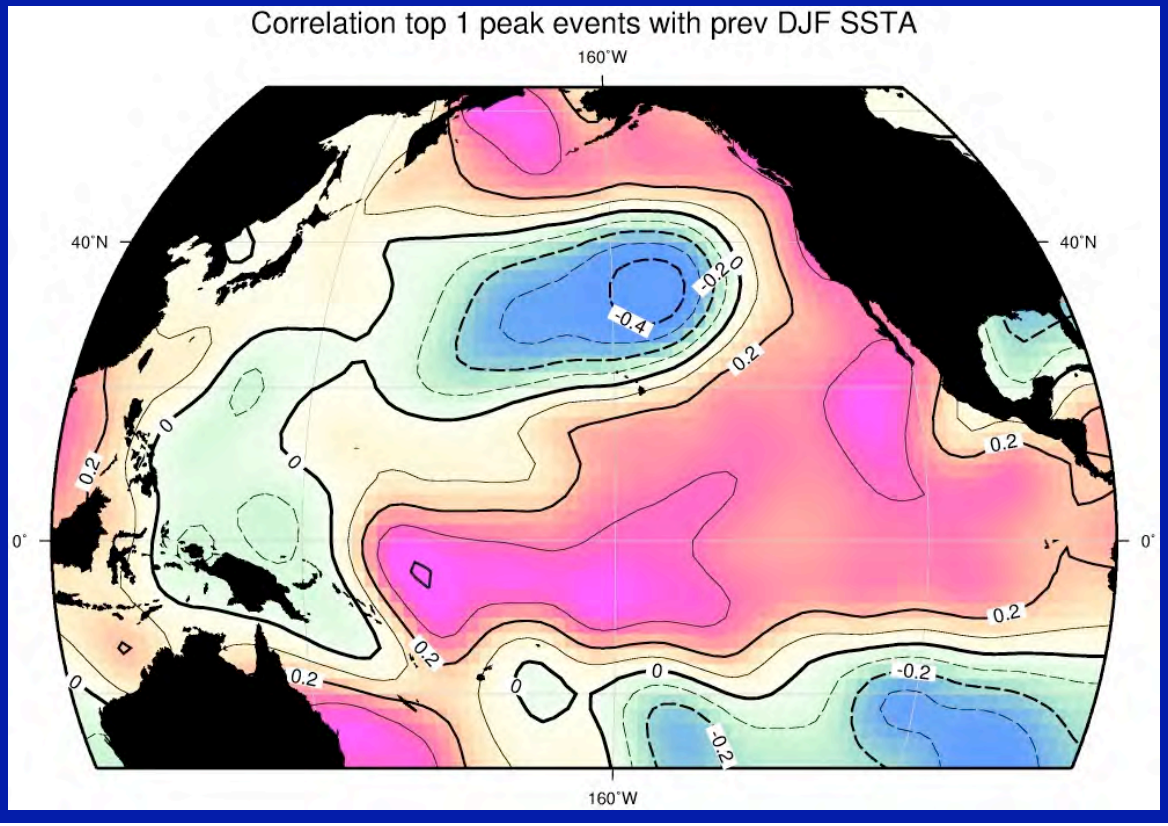





Summer peak days influenced by the Pacific Decadal Oscillation (PDO)

Contingency analysis of summer average temp (cooling degree days) based on PDO:

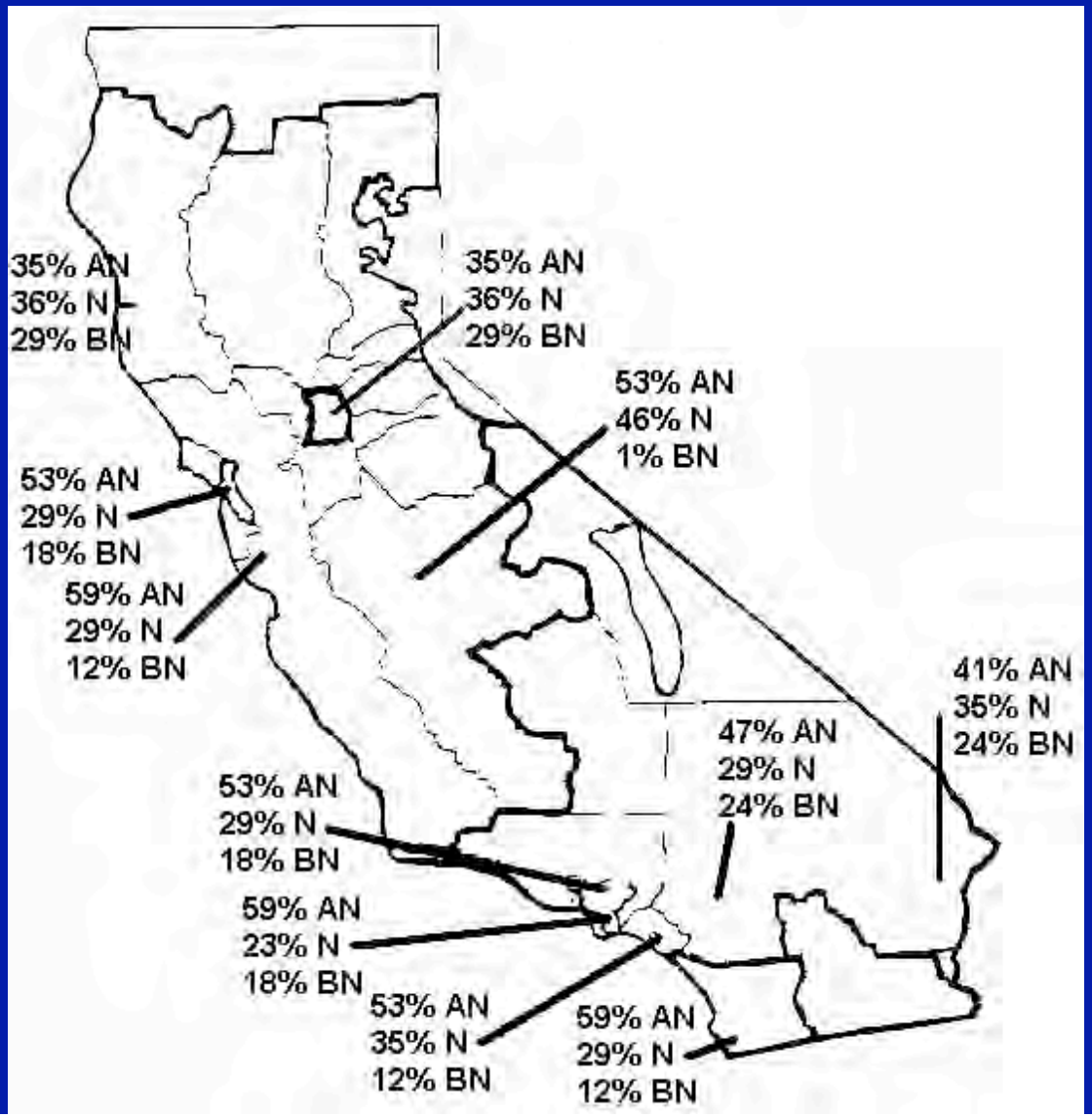
San Jose, CA

| | | < 331 | **Jun-Jul-Aug CDD** | > 414 |
|---|---|---|---|---|
| | | Below Norm | Norm | Above Norm |
| **PDO** | Below Norm | 53%** | 35 | 12*** |
| (Mar-Apr-May) | Norm | 35 | 36 | 29 |
| | Above Norm | 12*** | 29 | 59*** |

$\alpha$ = 0.01 => ***, 0.05 => **, 0.10 => *

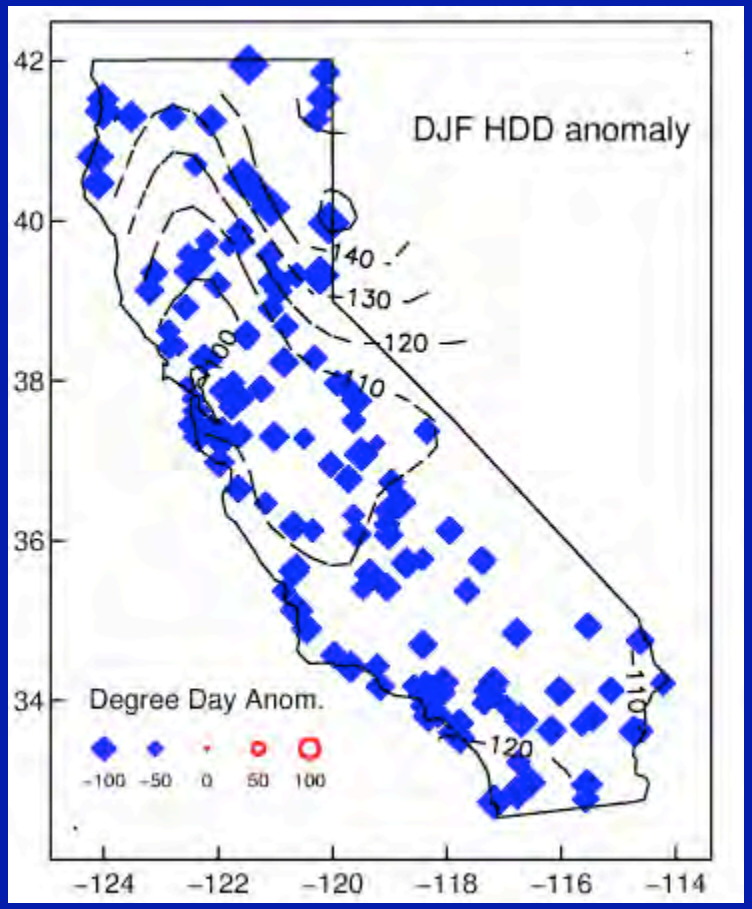
Eric Alfaro

# Summer CDD when PDO above normal in spring

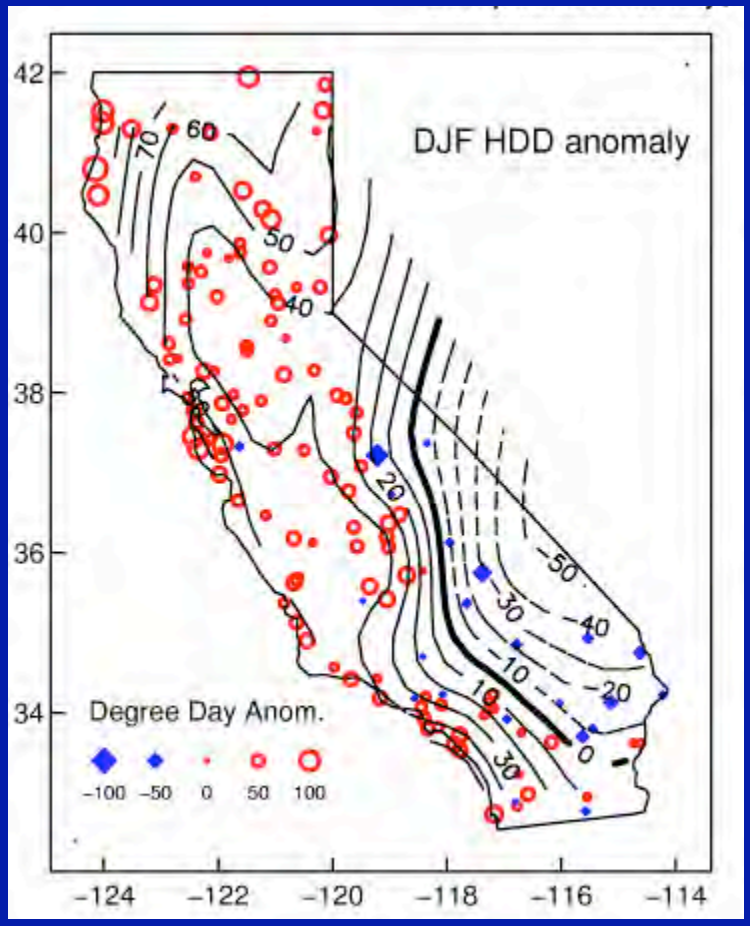


# Example 2: Winter natural gas use

Positive PDO

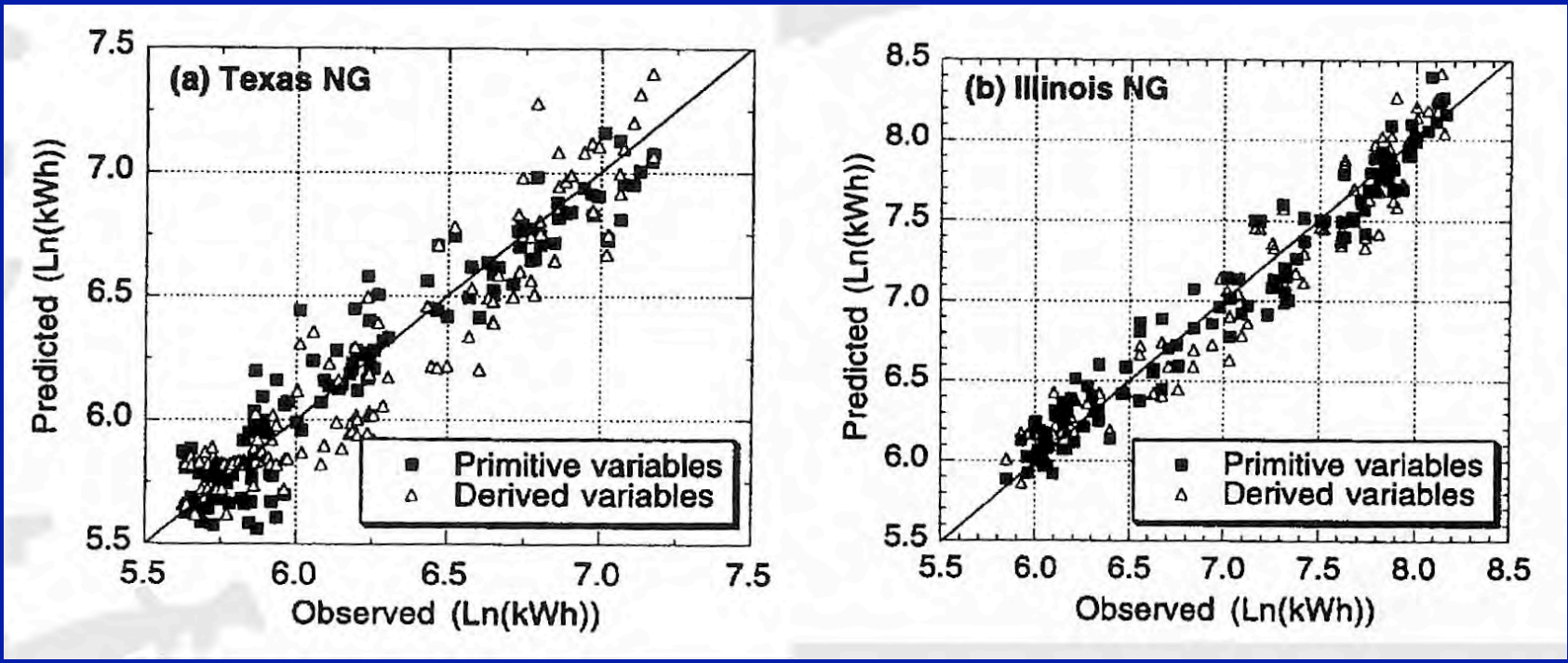



Negative PDO




Difference is about 150 HDD, or 5% of total HDD

# Convert to natural gas use…

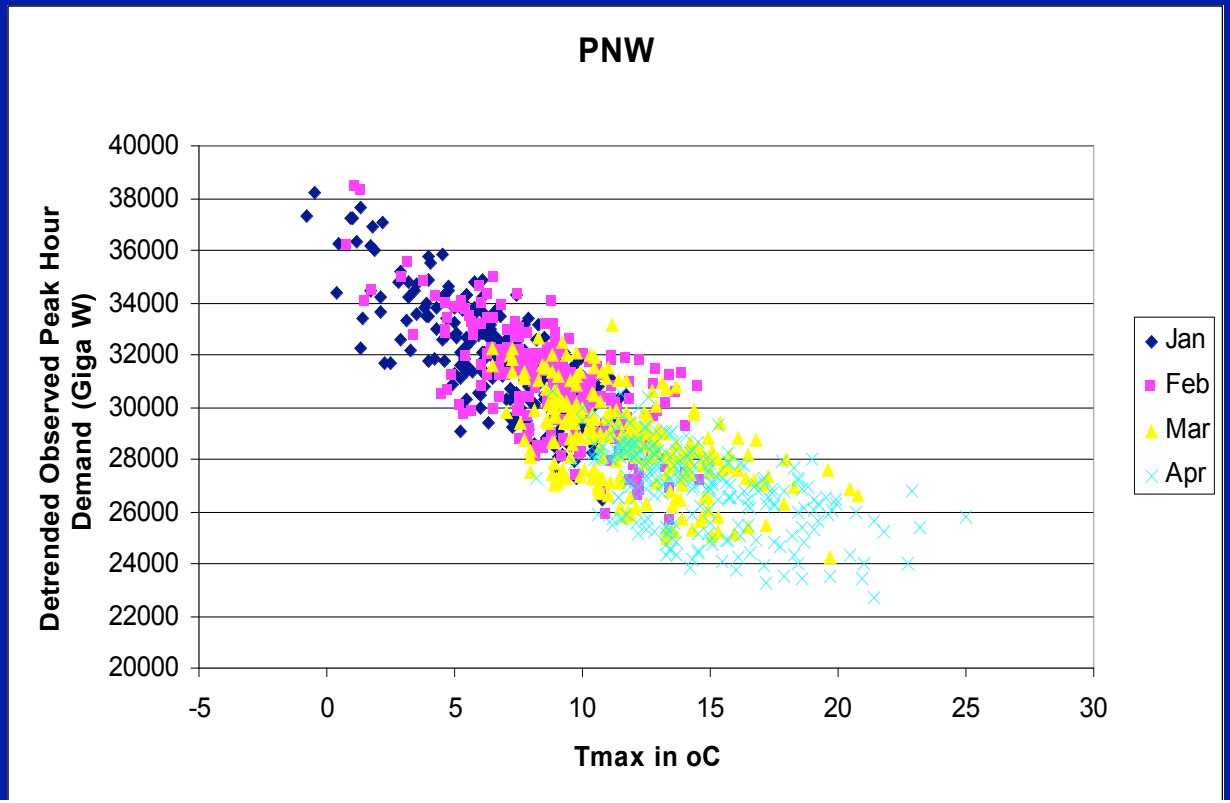



Sailor and Munoz, *Energy*, 1997

# Convert to natural gas use…

240 kWh/person/year * $35.6 \times 10^6$ people * 3.28 $ft^3$gas/kWh * 0.0078 $/ft^3$

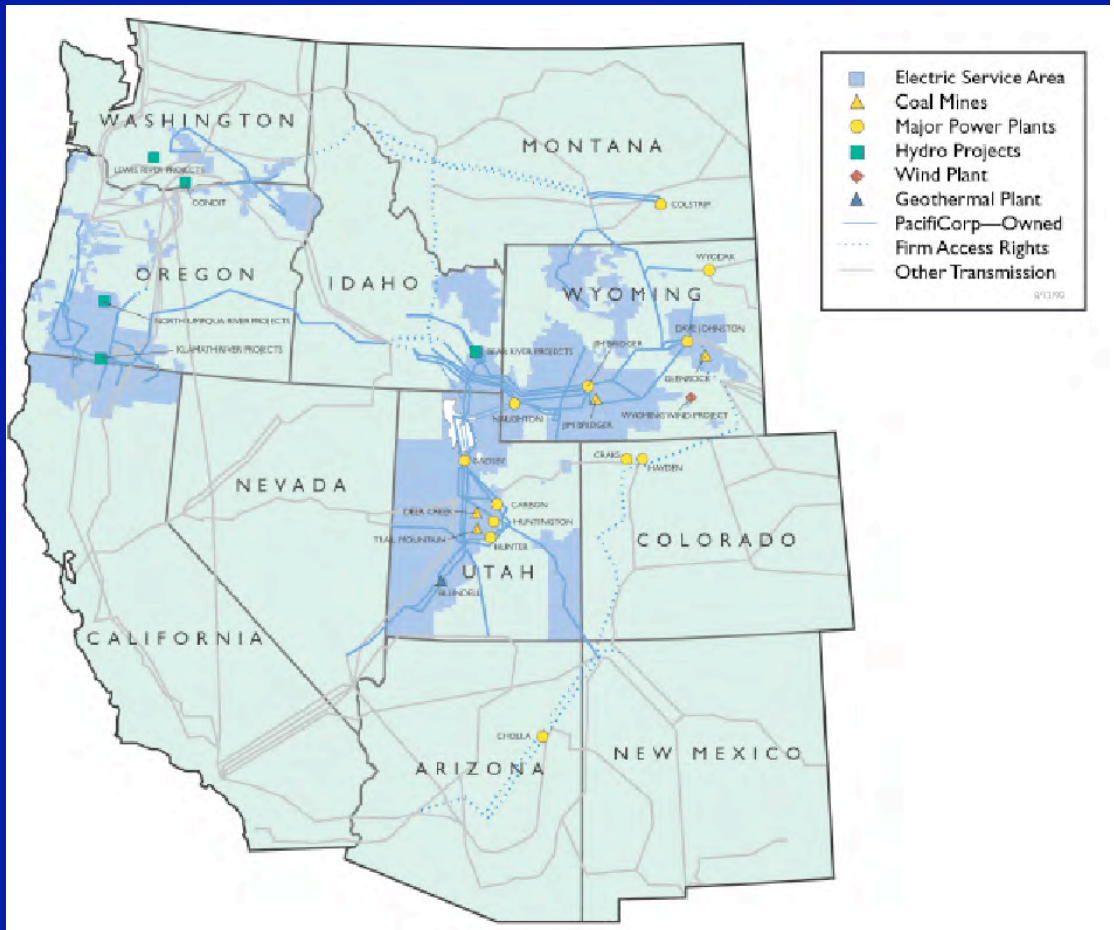
= $220 M for California



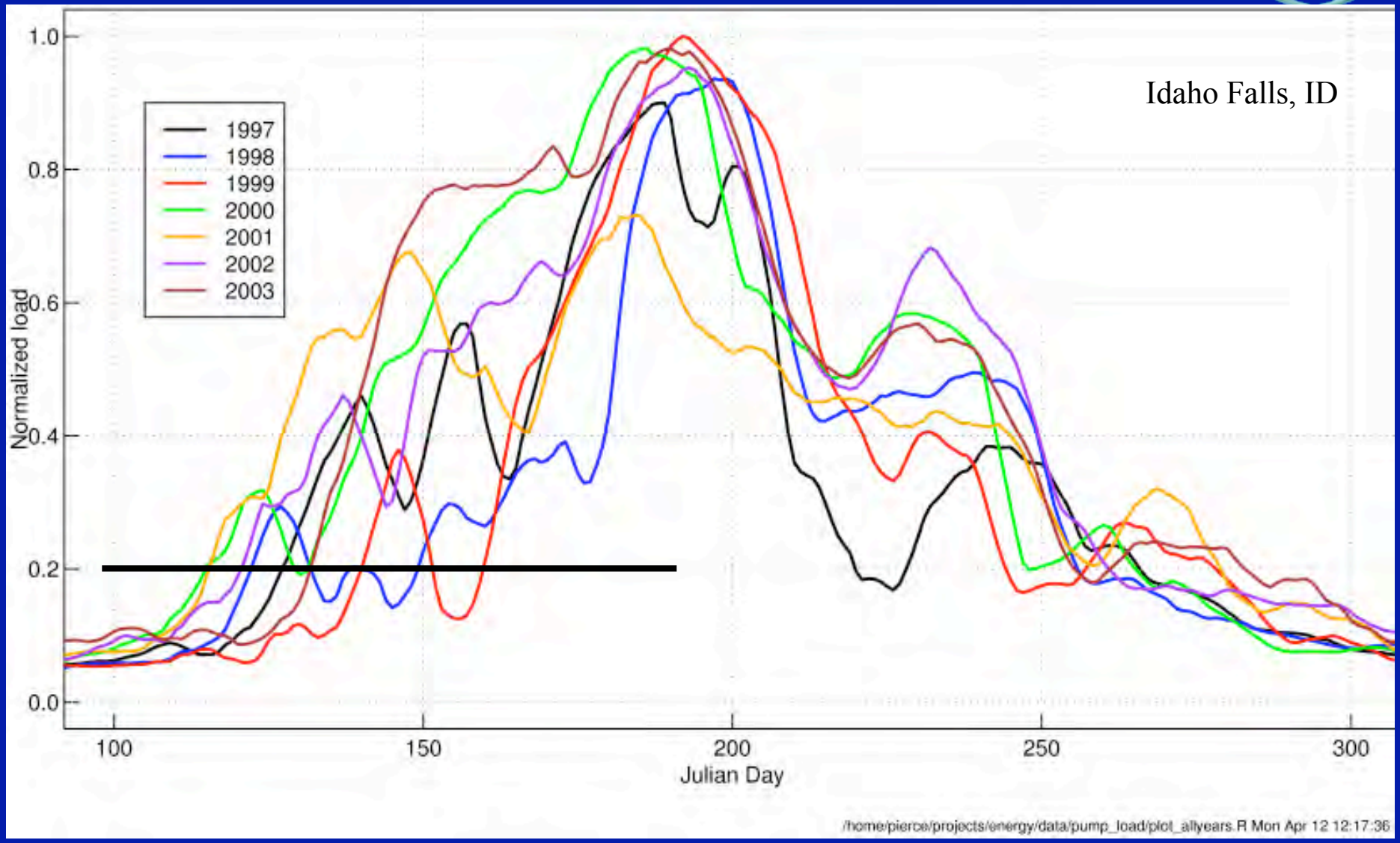

Nathalie Voisin et al., 2005

# Example 3: Western pump loads

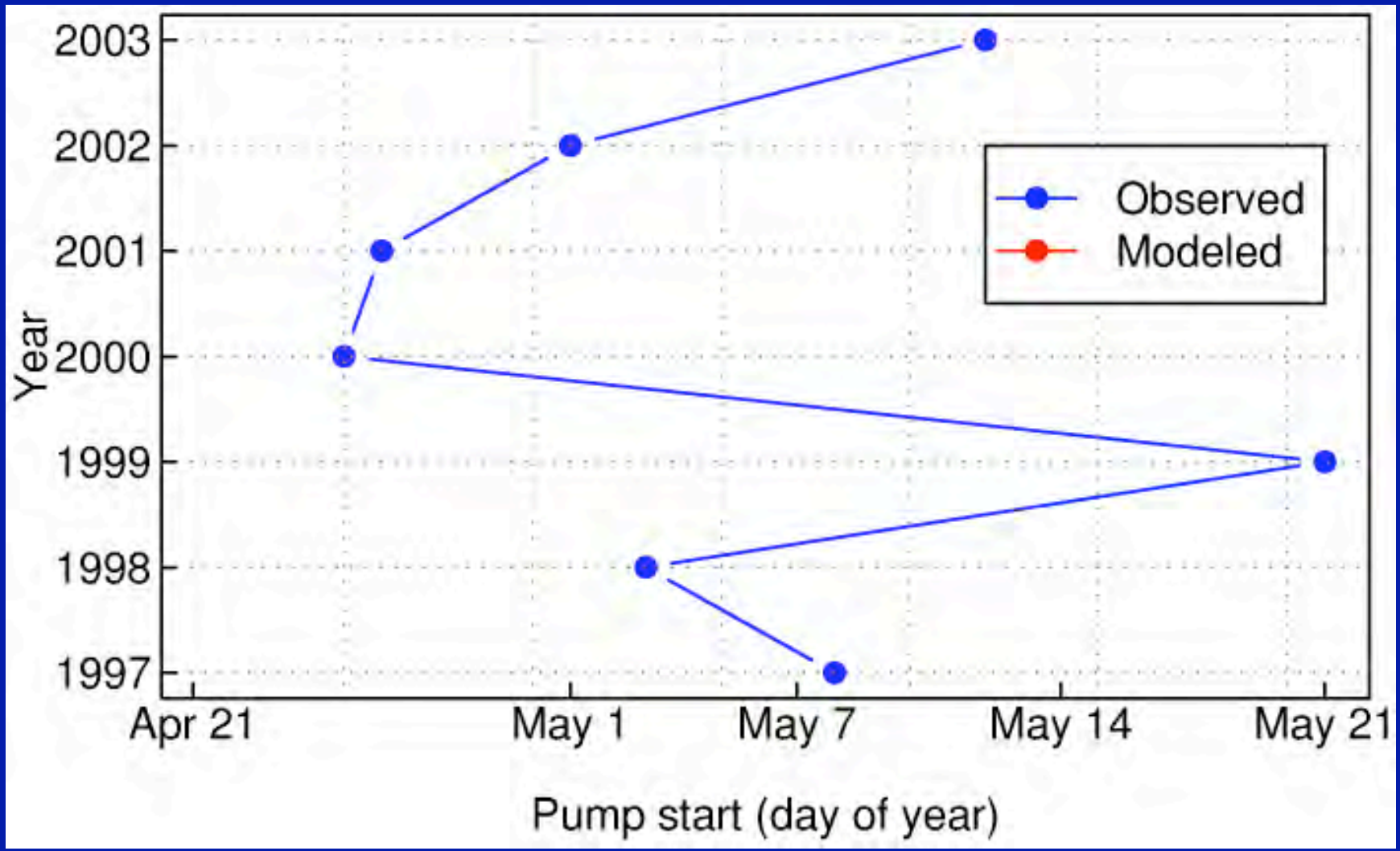
- Electricity use in Pacific Northwest strongly driven by irrigation pumps
- When will the pumps start?
- What will total seasonal use be?



# Irrigation pump start date



# Pump start date

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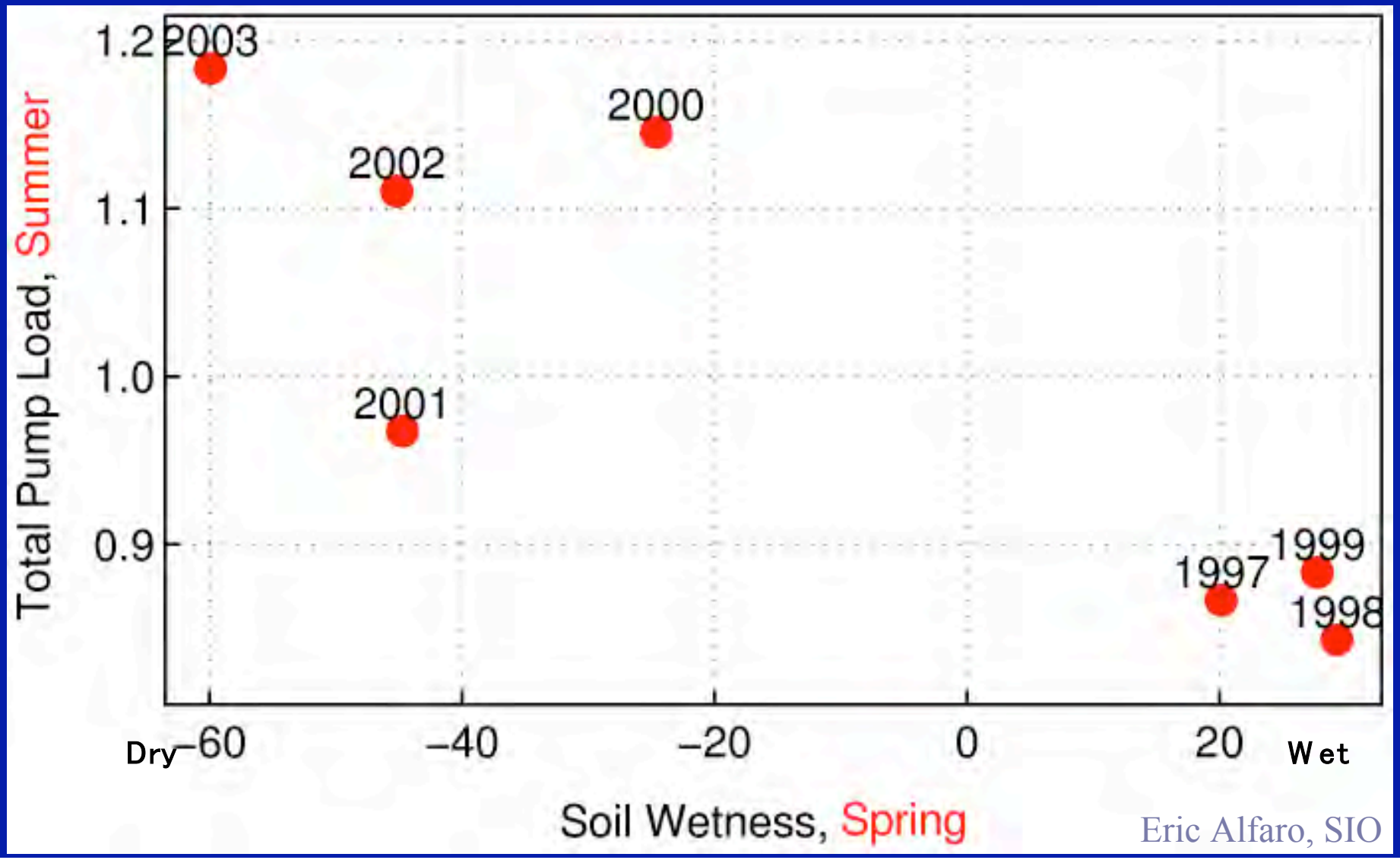
# Total load affected by soil moisture

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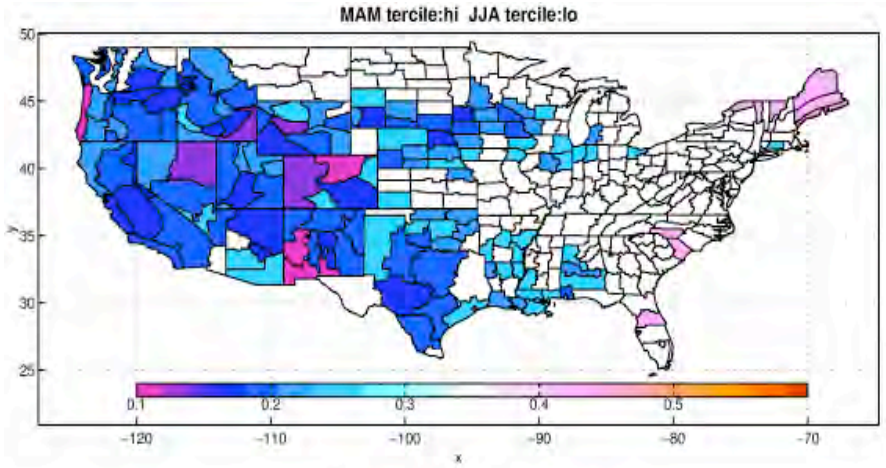
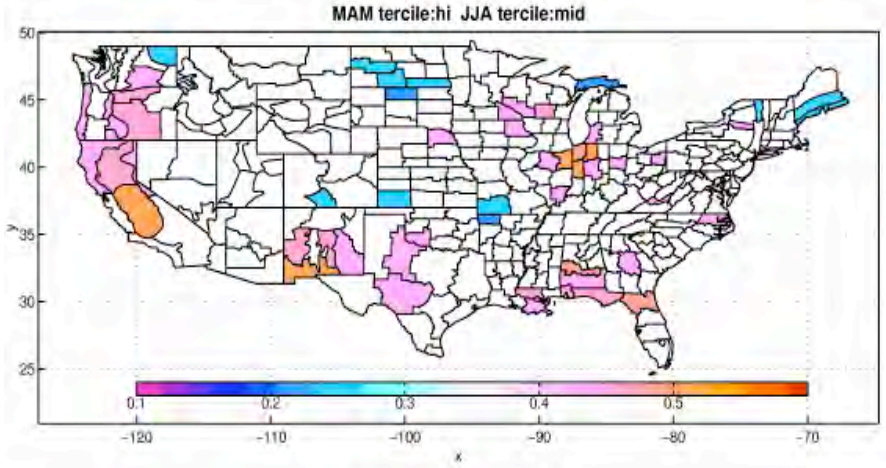
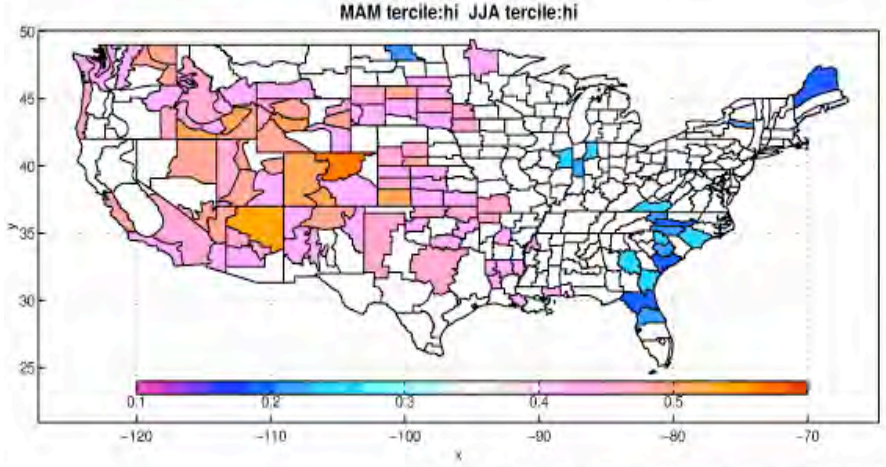


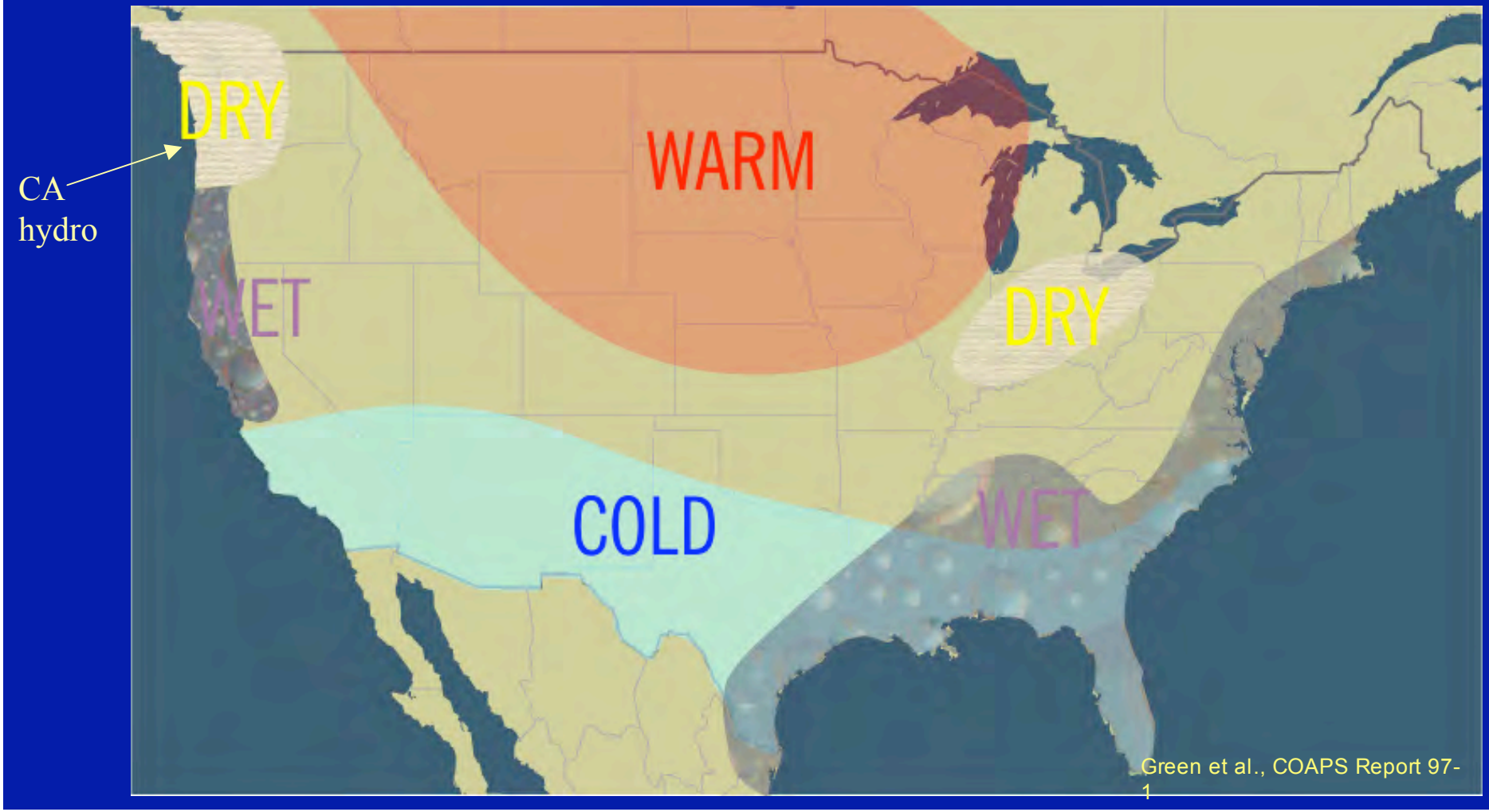



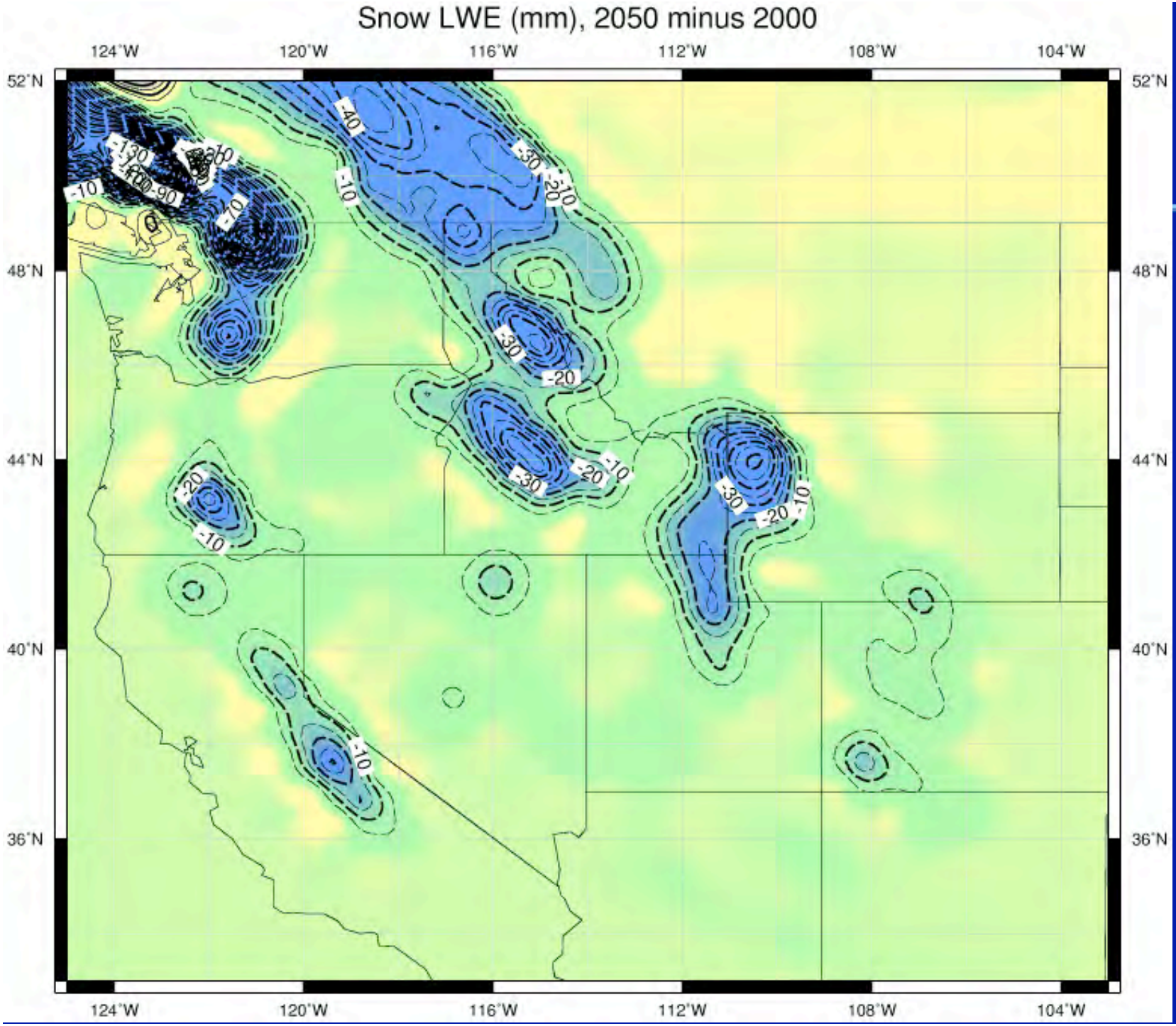

Predicting summer temperature based on spring temperature

# Example 4: Hydropower

Typical effects of El Nino:




Green et al., COAPS Report 97-1

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Leung et al., Climatic Change, 2004

# Conclusions

1. Climate change might manifest through seasonal modes
2. Adaptation to climate change might use seasonal forecasts
3. Pacific Decadal Oscillation correlated with:
   - Summer peak electricity usage
   - Winter natural gas use
4. Spring soil moisture affects summer temperatures and irrigation pump loads
5. Hydropower influenced by El Nino, and changing snowpack in the future world


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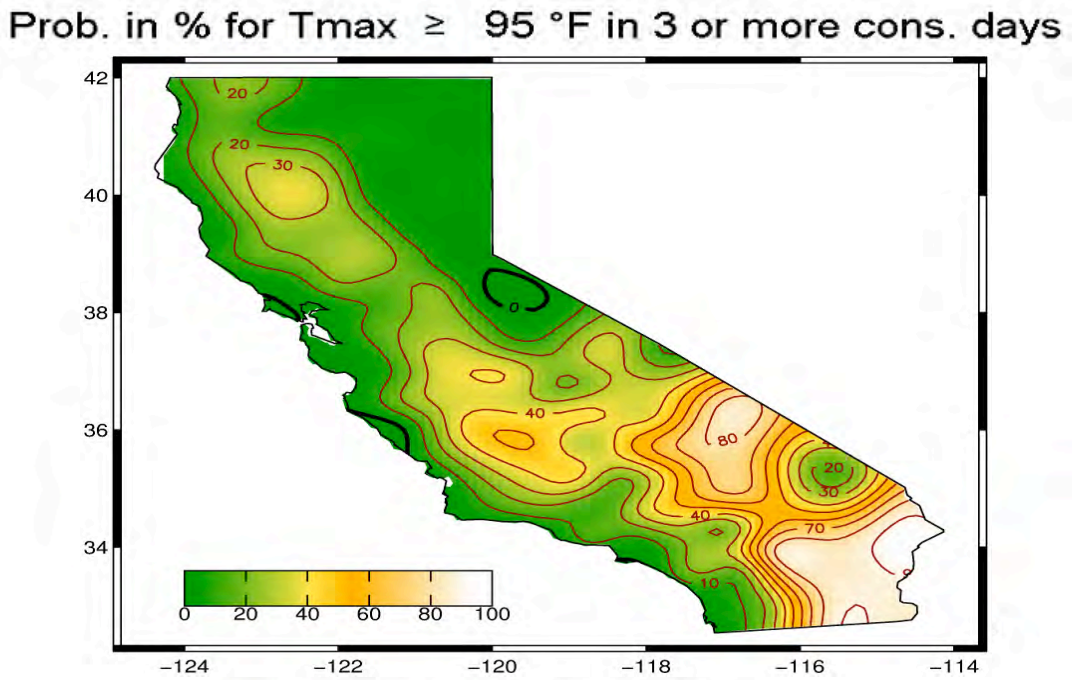
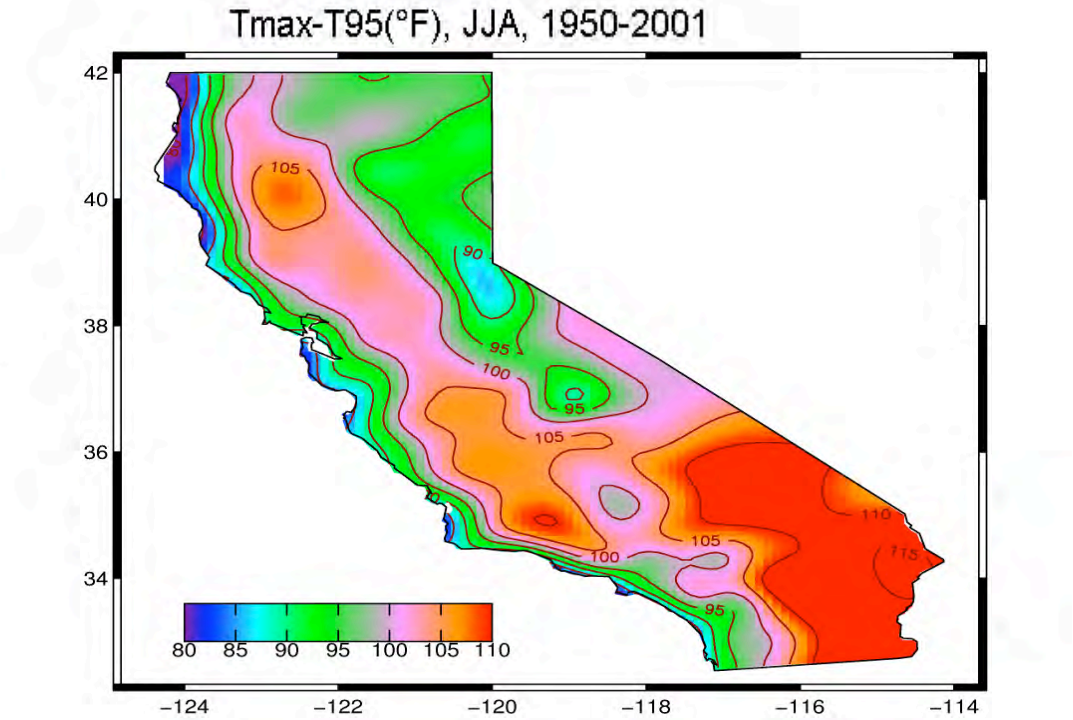
# Extreme events

Same *temperature* threshold (e.g. 95 °F) =>

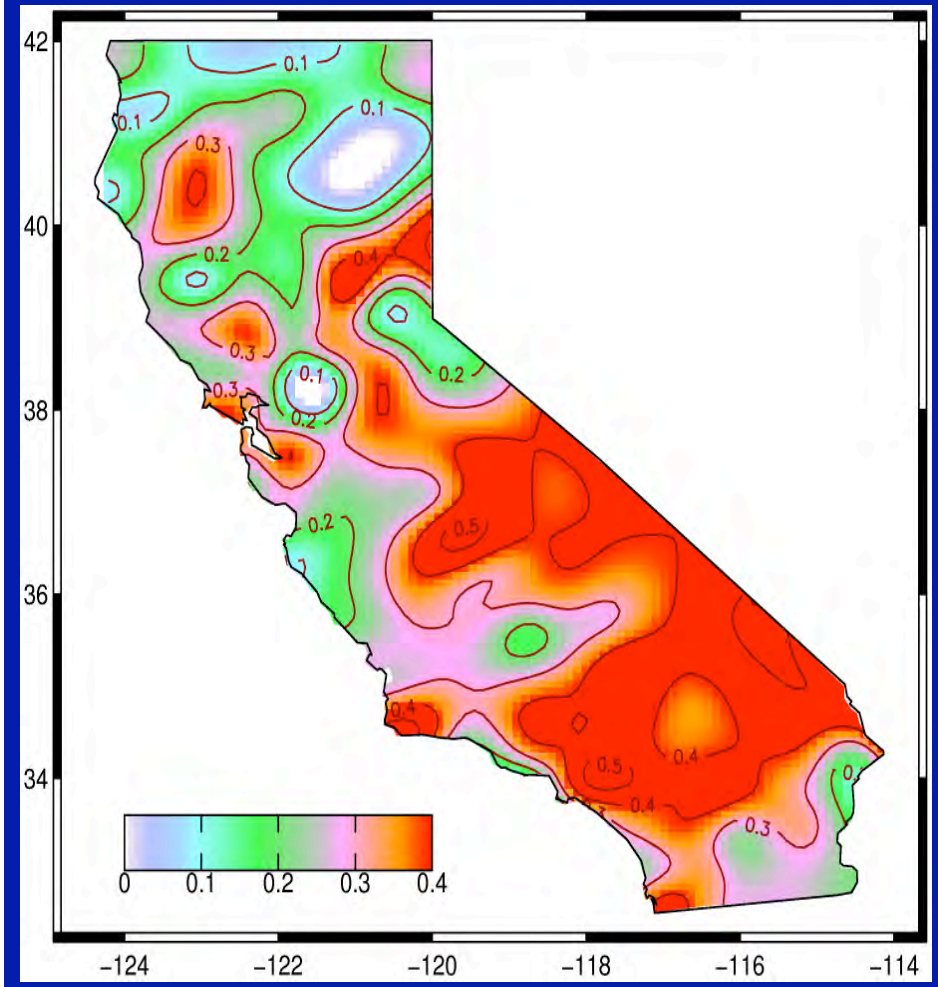
Same *percentile* threshold (e.g. 95th) =>



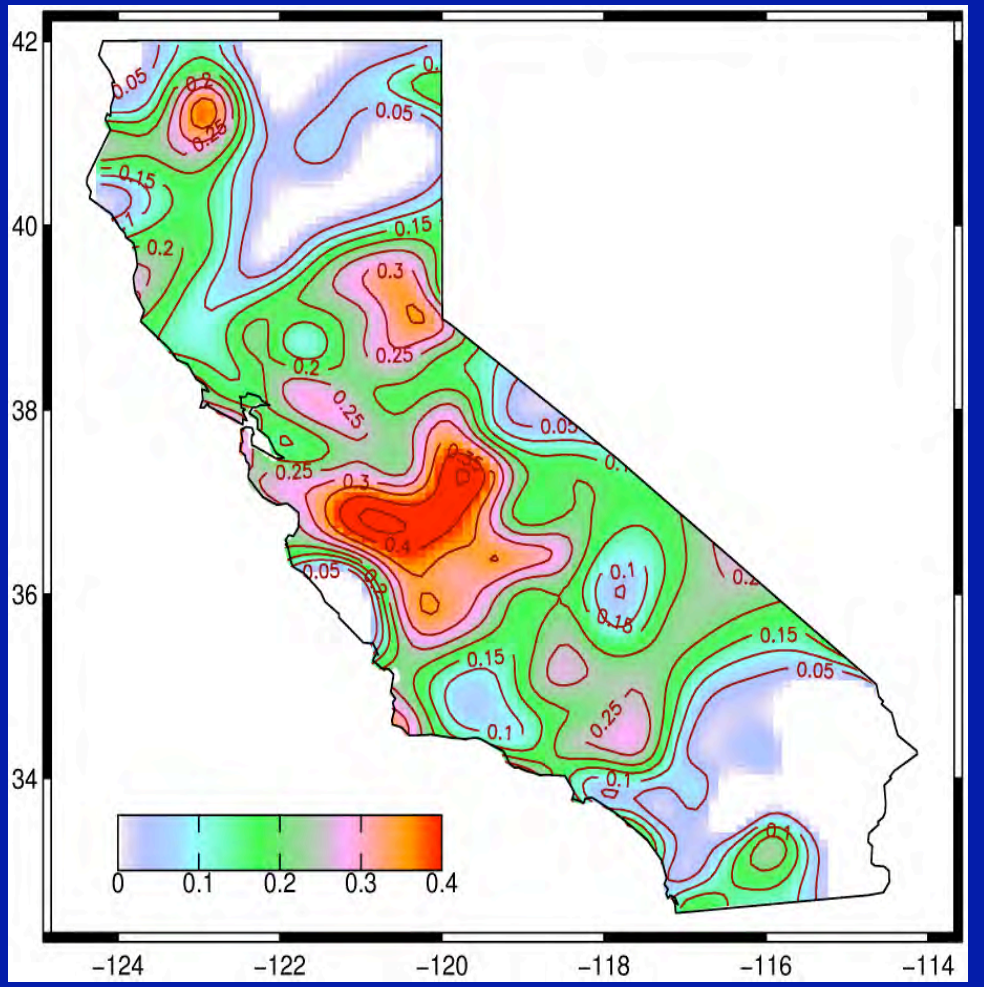



# Spring SST predicting summer temperatures

CDD

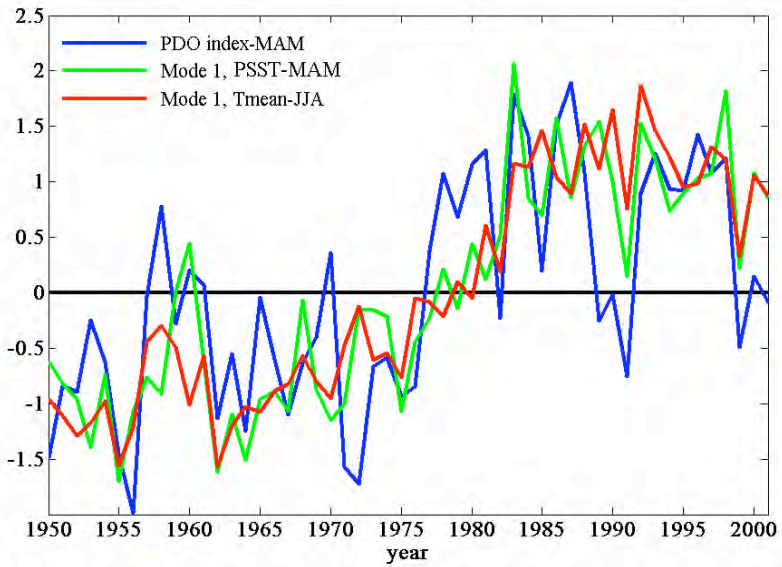


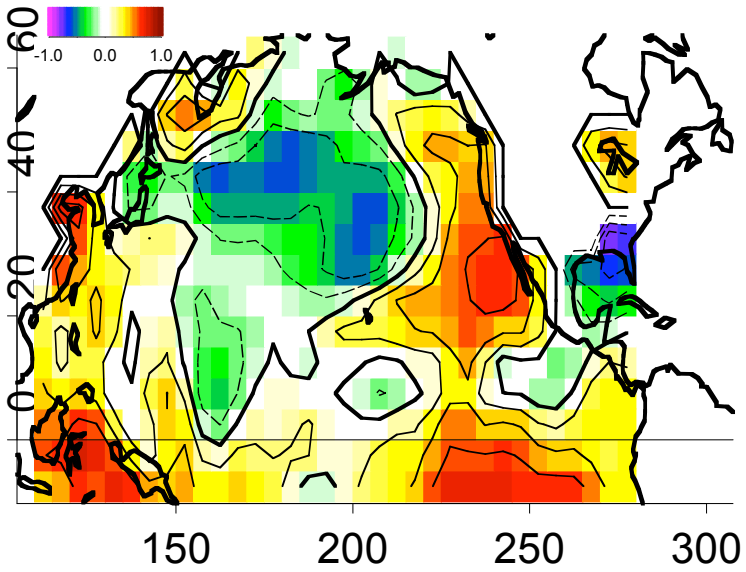

Tmax-95th percentile



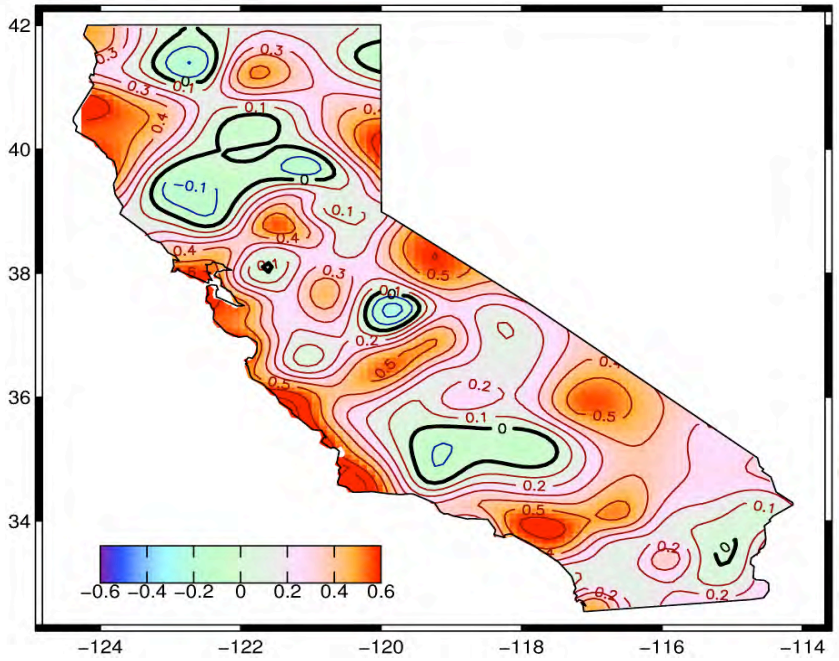
# Relationship PDO => California Summertime Temperatures

Correlations, Mode 1-PSST, MAM

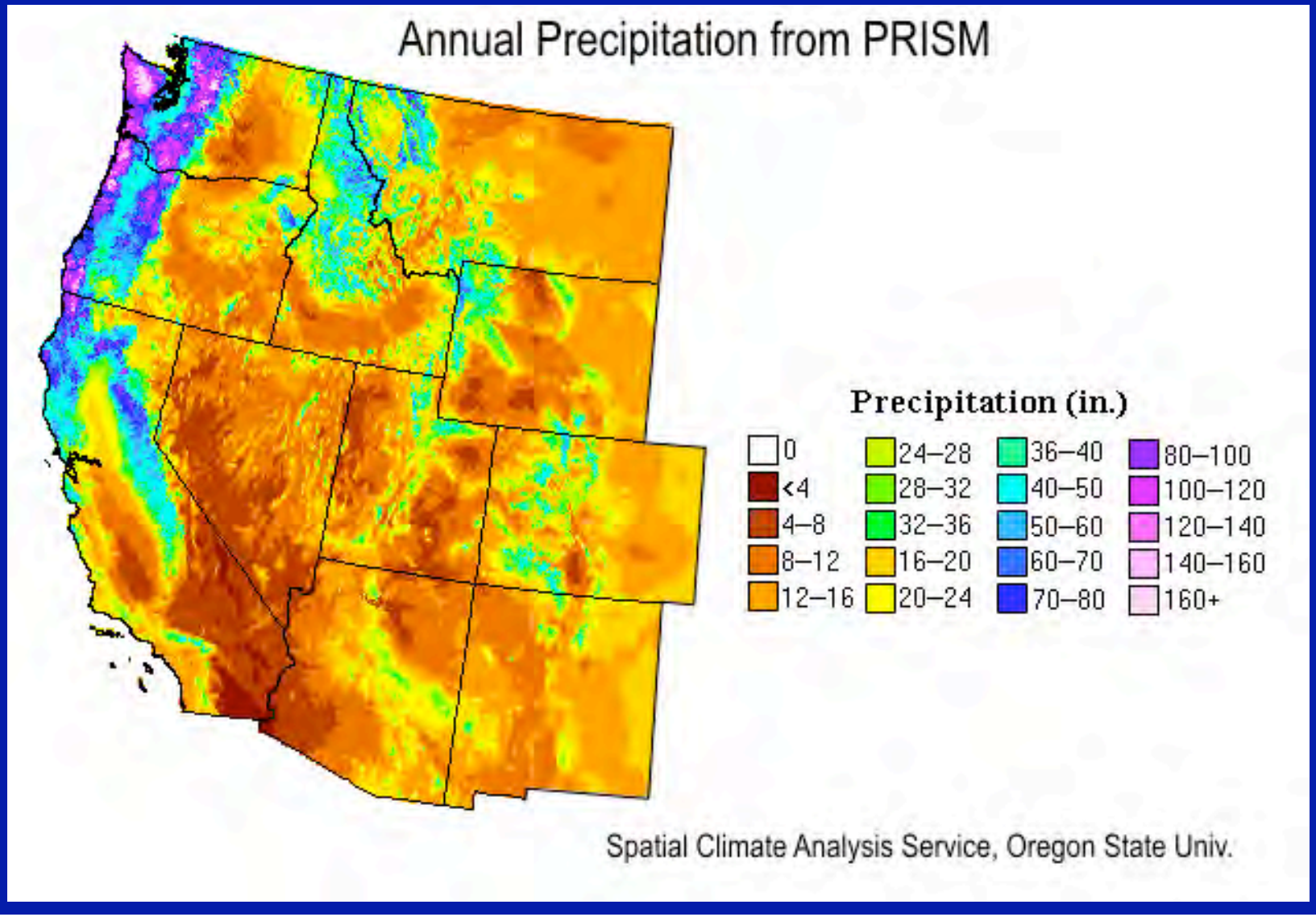


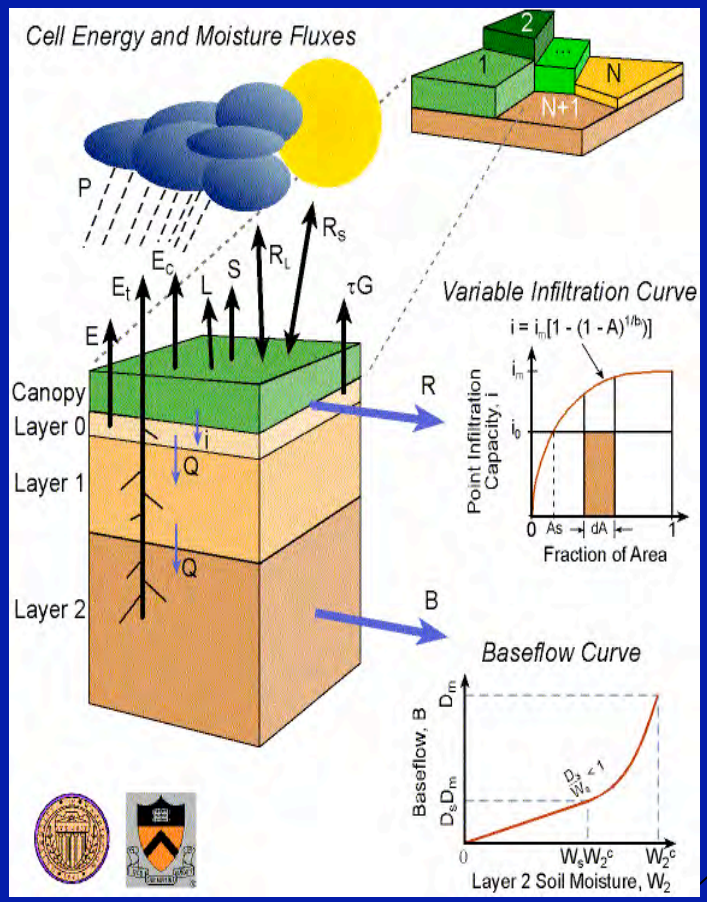

Correlations, Mode 1-Tmean, JJA =>

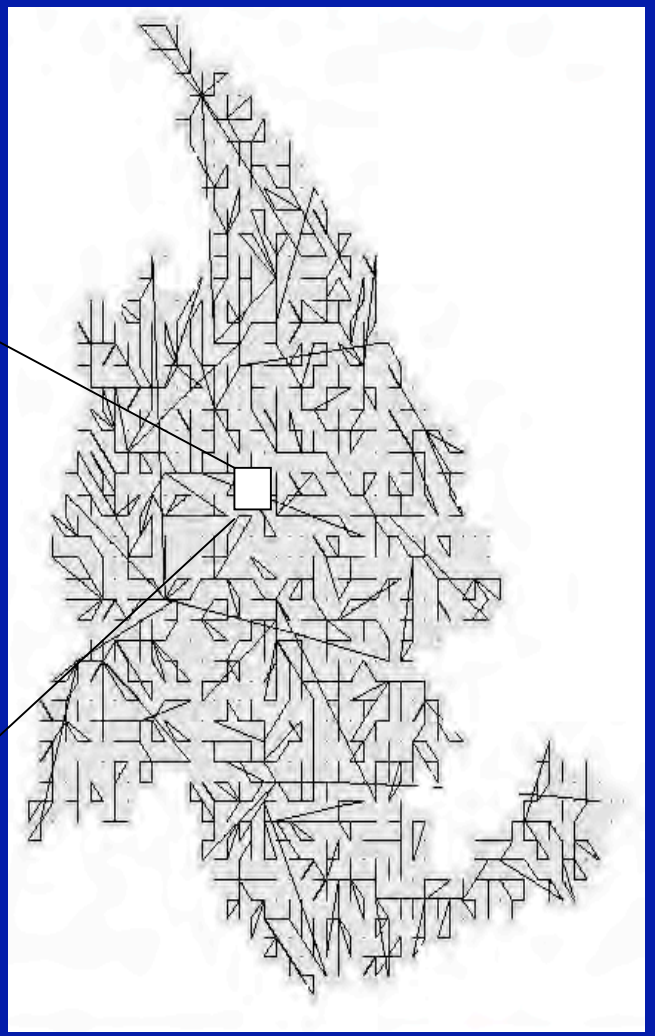


# Step 1: Develop climate forcing fields



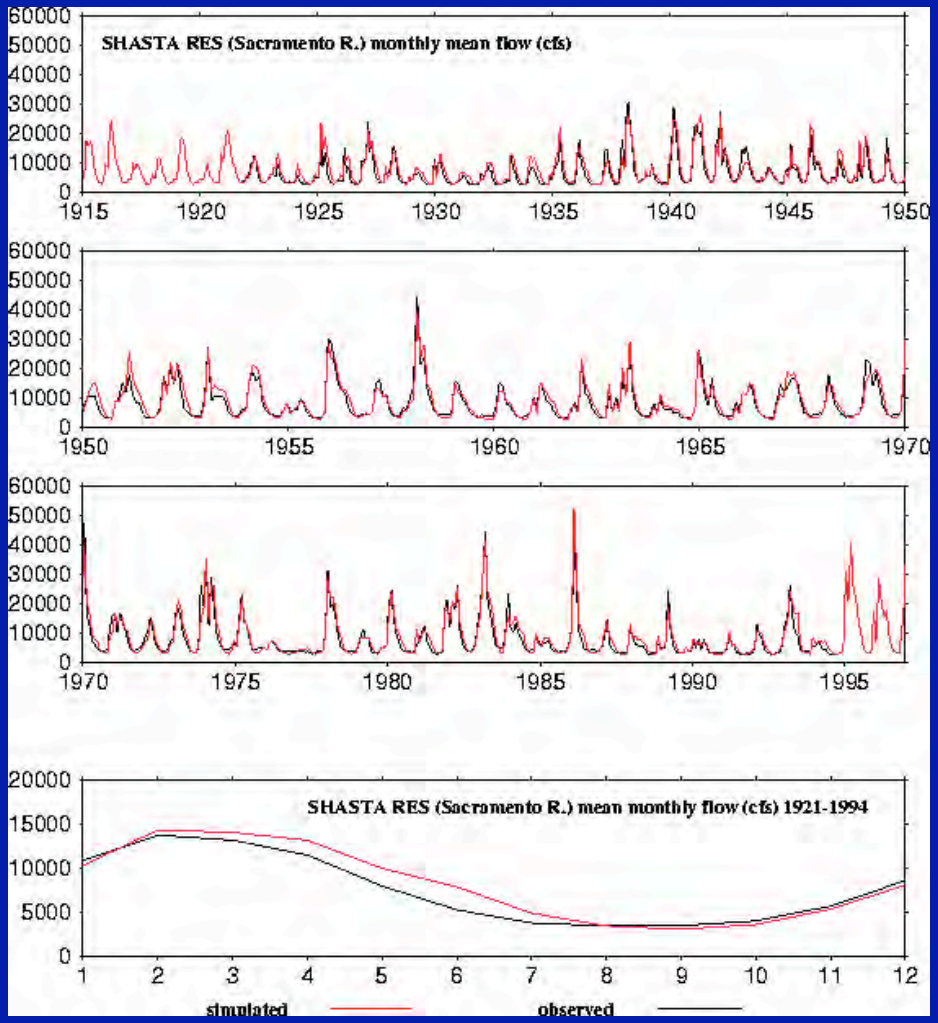
# Step 2: Apply to soil/streamflow model

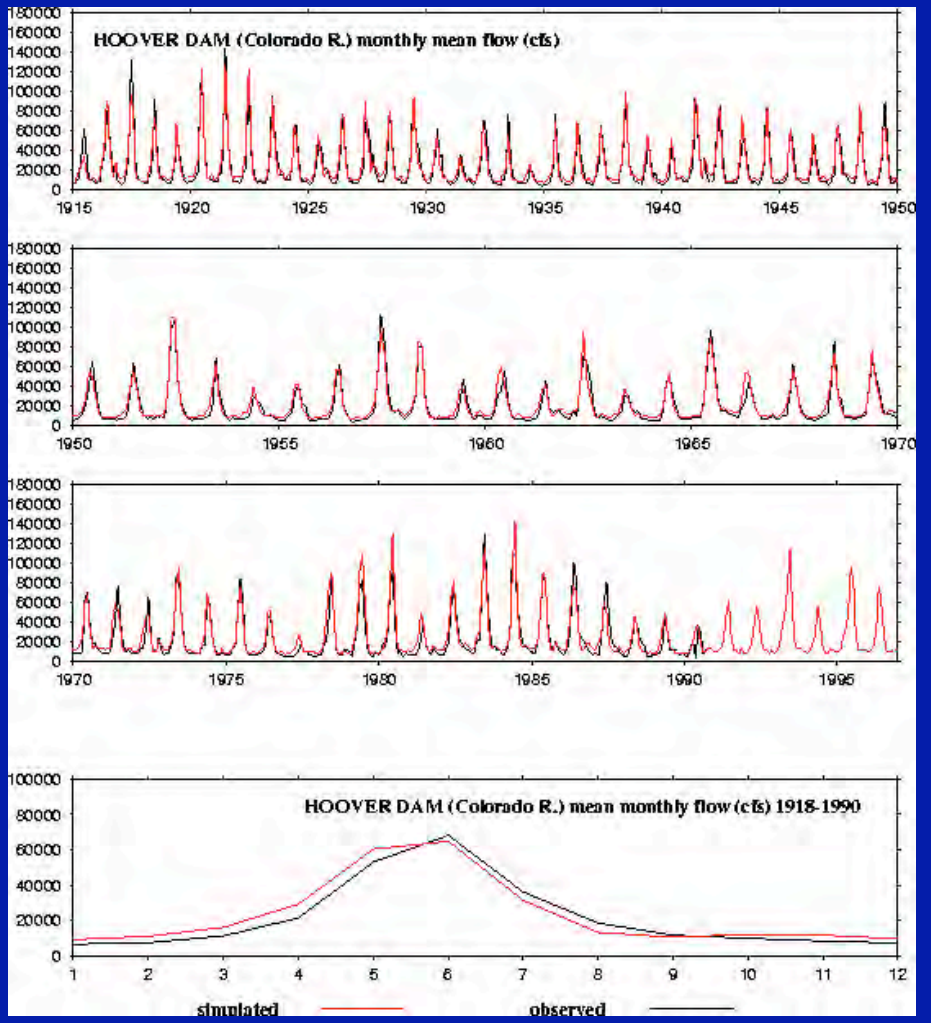


Nathalie Voisin et al., Univ. Washington, 2004

# Step 3. Verify streamflow




Nathalie Voisin et al., Univ. Washington, 2004

# Step 4. Apply to reservoir model

- ColSim (Columbia Simulation) for the Pacific Northwest
- CVmod (Central Valley model) for Sacramento-San Joaquin basin
- Use realistic operating rules:
  - Energy content curves (ECC) for allocating hydropower
  - US Army Corp of Engineers rule curves for flood prevention
  - Flow for fish habitat under Biological Opinion Operating Plan
  - Agricultural withdrawal estimated from observations
  - Recreational use of Grand Coulee Dam reservoir

# Major components of CVmod

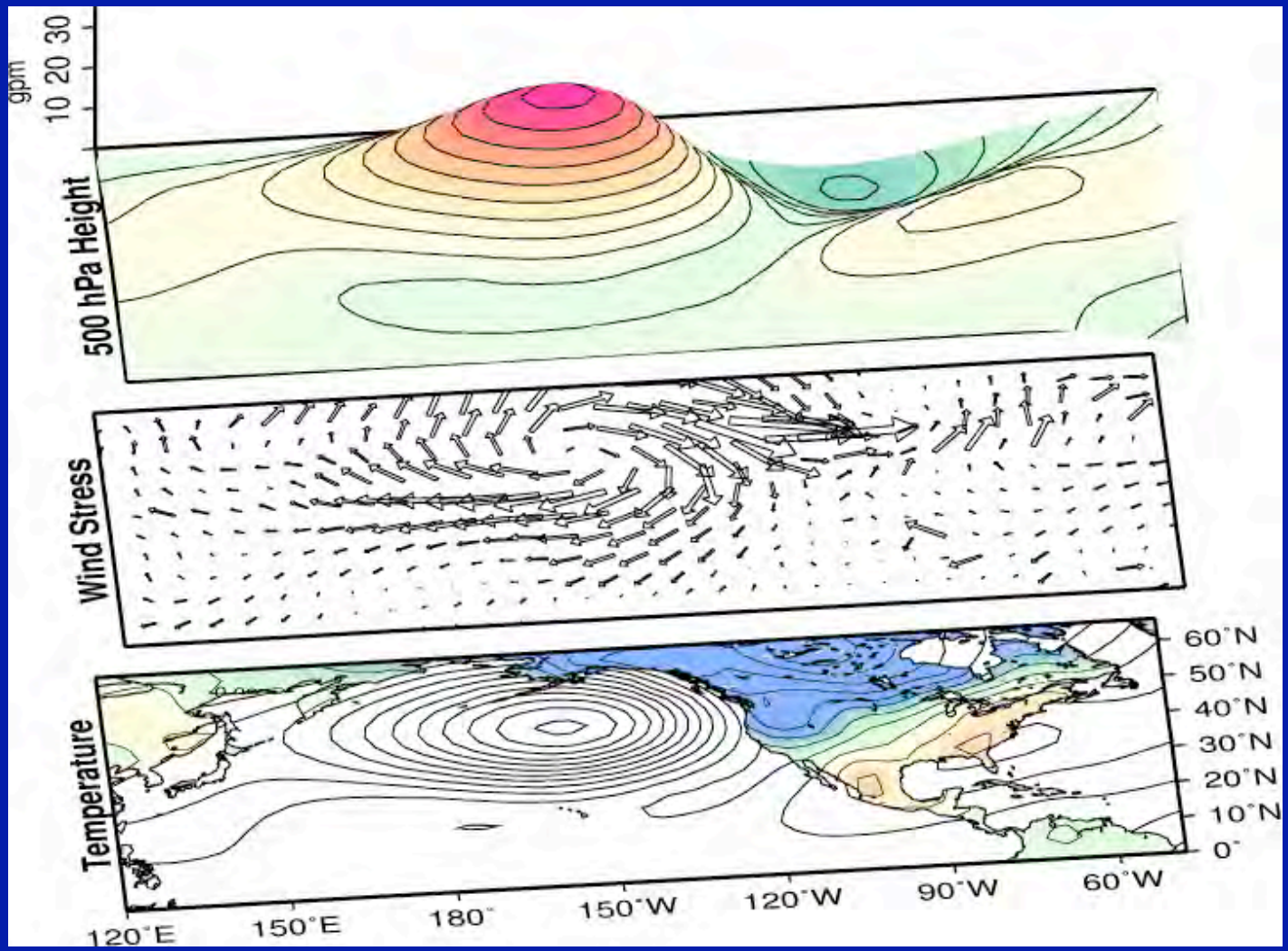
| | | | |
|---|---|---|---|
| Lake Shasta | Flood control, navigation, fish conservation | USBR | USBR: Bureau of Reclamation |
| Lake Trinity | Water supply, hydropower, fish conservation | USBR | DWR: CA Dept Water Resources |
| Whiskeytown Reservoir | Flood control, hydropower | USBR | EBMUD: East Bay Municipal District |
| Lake Oroville | Flood control, water supply, hydropower, water quality, environmental conservation | DWR | MC: Merced County |
| Folsom Lake | Flood control, water supply, hydropower | USBR | TID: Turlock Irrigation District |
| Pardee/Camanche Resv. | Flood control, water supply | EBMUD | COE: US Army Corp of Engineers |
| New Hogan Reservoir | Flood control, water supply | COE | |
| New Melones Reservoir | Flood control, water supply, water quality, hydropower | USBR | |
| New Don Pedro Res./Lake McClure | Flood control, water supply | TMID, MC | |
| Millerton/Eastman/Hensley | Water supply, recreation | USBR, COE | |
| Sacramento-San Joaquin Delta | Water supply, water quality | USBR, DWR | |
| San Luis Reservoir | | USBR, DWR | |

Van Rheenen et al., Climatic Change, 2004

# Hydropower summary

- Strong climate-related year to year variability in CA hydropower
- Working on forecasting that variability using same techniques that worked for summer temperatures
- Possible benefits of such forecasts include better water/hydropower management and reduced costs

# Why the NPO matters

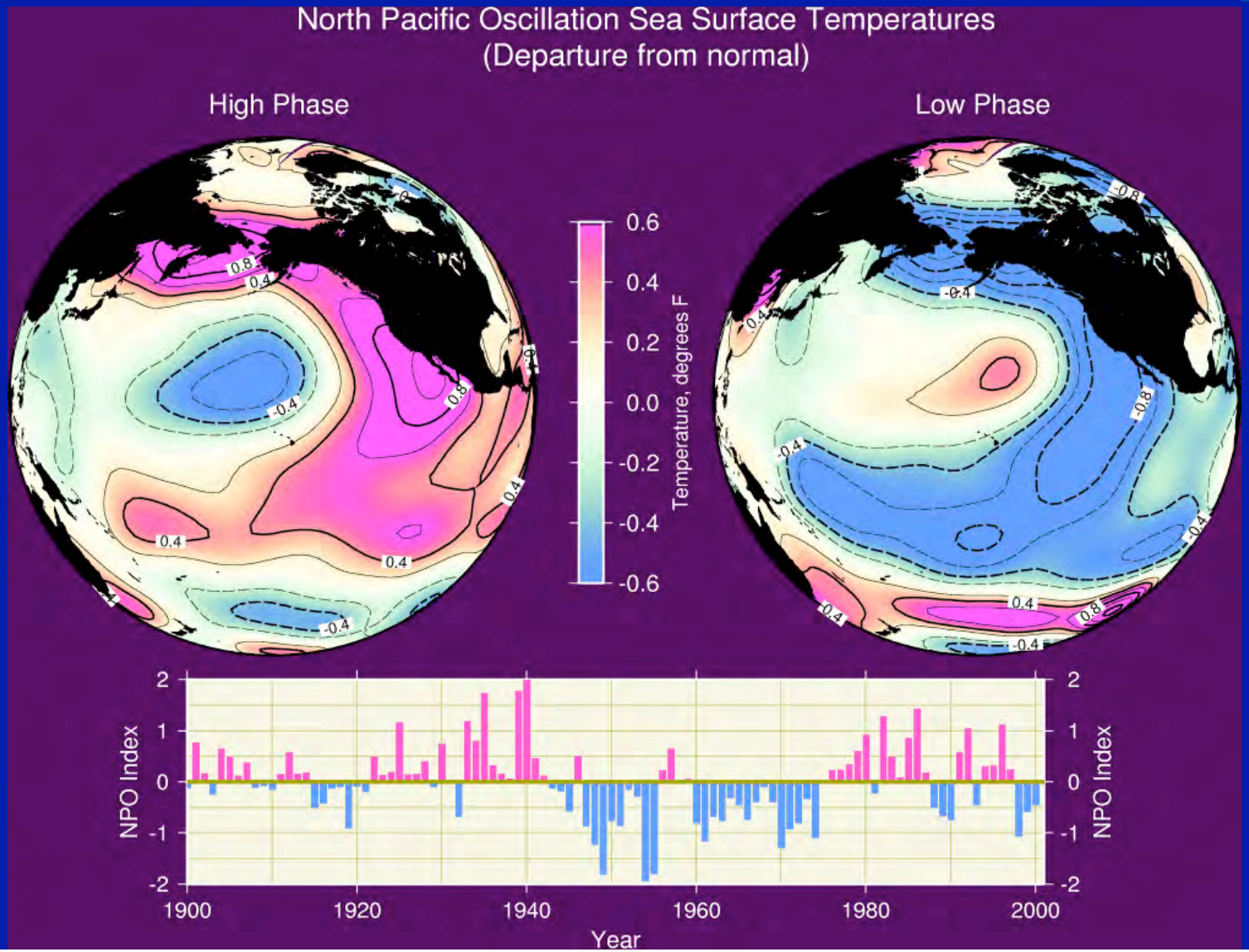



Higher than usual pressure associated with the NPO…

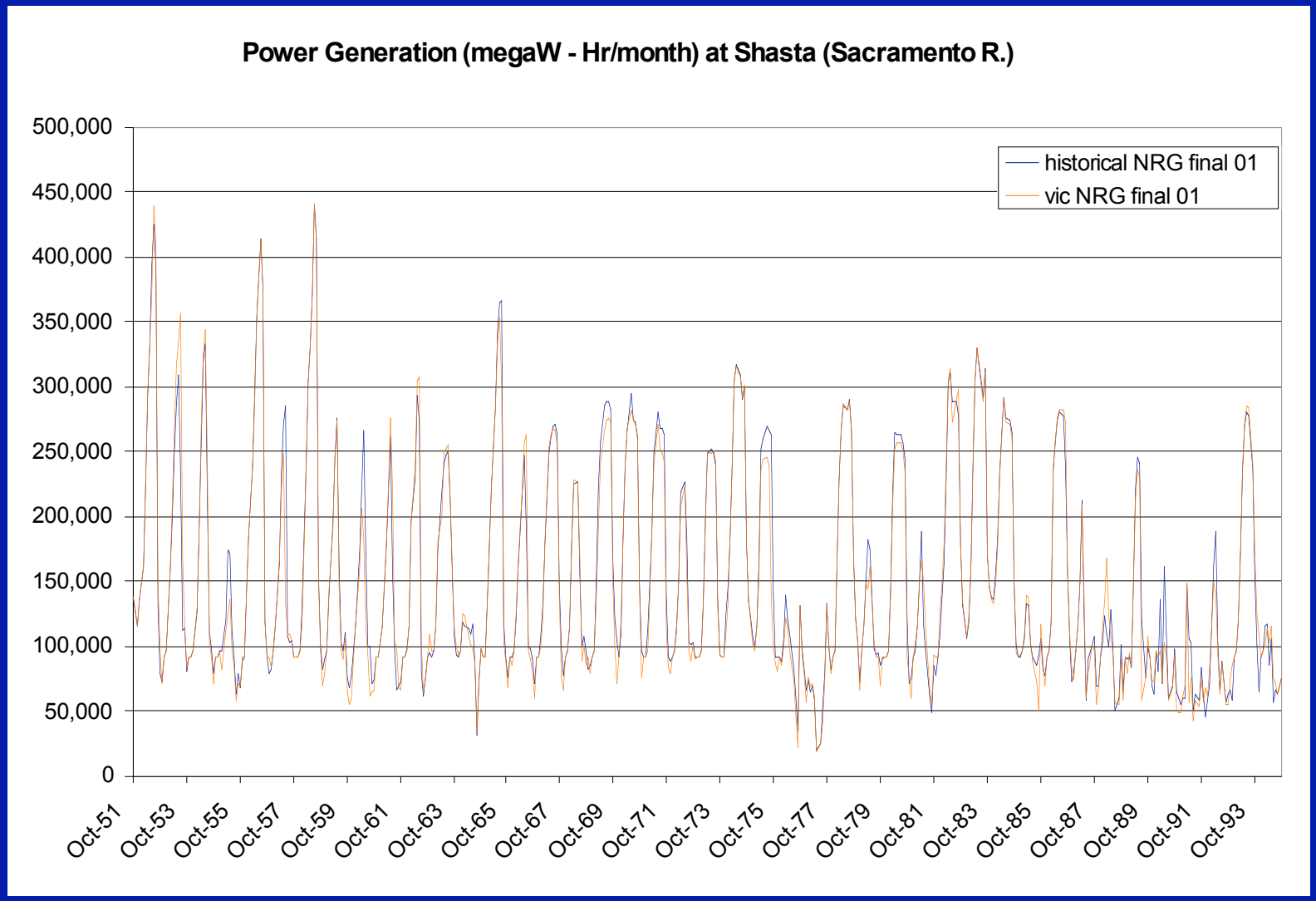
generates anomalous winds from the north west…

…which bring more cold, arctic air into the western U.S. during winter

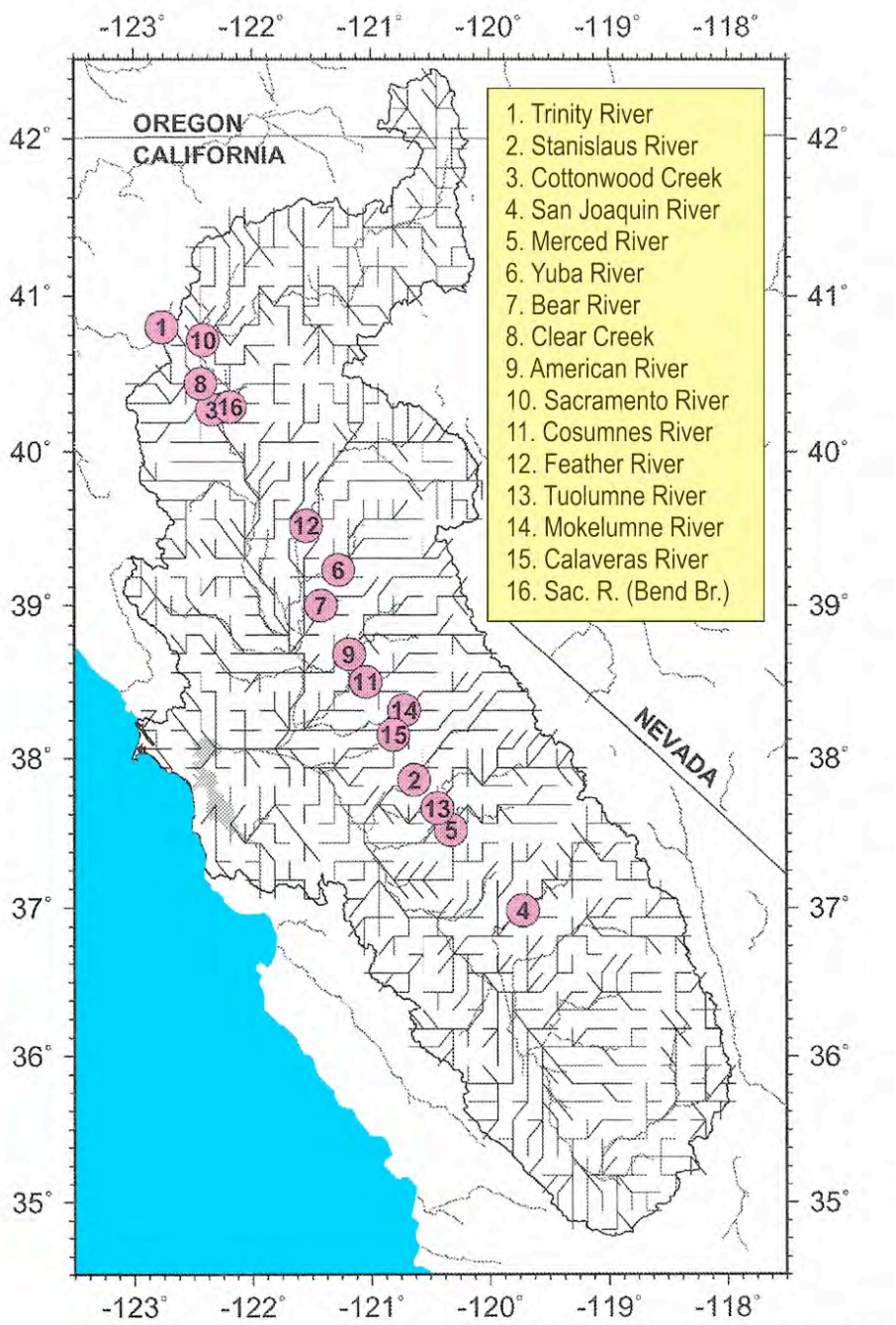
# 4. Pacific Sea Surface Temperatures



# Hydropower production at Shasta dam




N. Voisin et al., Univ. Wash., 2004




Van Rheenen et al., *Climatic Change*, 2004